JP90350

ON-THE-JOB TRAINING

PACKAGE PROGRAM



# RADIOLOGY

# SPECIALIST

DEPARTMENT OF THE AIR FORCE

# Program Number JP90350
# RADIOLOGY SPECIALIST

. . . . ON THE JOB TRAINING PROGRAM

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OJT PROGRAM
NUMBER JP 90350

DEPARTMENT OF THE AIR FORCE
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# FOREWORD

1. Purpose. This program is designed as a guide for supervised training on-the-job for Air Force personnel. Directives and responsibilities for this type of training are set forth in Air Force Regulation 52-2, "On-The-Job Training."

2. Contents. This program contains the OJT Outline and Training Standard, job knowledges, work experiences, references and guidance to develop the required proficiency in the designated Air Force Specialty (AFS).

3. Recommendations. Recommendations for the improvement of this program are invited. Recommendations should be forwarded to the Commander, Air Training Command, Randolph Air Force Base, Texas.

4. Distribution.

a. Initial distribution requirements are determined and distribution is accomplished in the same manner as for other Air Force publications which receive functional distribution. (See Sections 4 and 7, Chapter 4, AFM 5-4.)

b. Bulk shipment is made to USAFE and PACAF distribution depots for distribution within their commands. Direct distribution is made to all other installations.

c. Additional copies may be requisitioned in accordance with AF Manual 5-4. An index of OJT Packaged Programs is published quarterly, listing programs that are currently rescinded or superseded, and future programs. Requisitions should be submitted to Shelby Air Force Depot by the Publications Distribution Officer concerned, on AF Form 124. Quantities requested should be held to the minimum number necessary to conduct the OJT Programs.

5. Individual Issue. This publication is organizational rather than personal property and is authorized to remain in the personal possession of individuals to whom issued only so long as it is required in the performance of the duties for which it is designed.

BY ORDER OF THE SECRETARY OF THE AIR FORCE:

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OFFICIAL:

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Colonel, USAF
Director of Administrative Services

DISTRIBUTION: F

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# INTRODUCTION

Just what is meant by the term "on-the-job" training? The following official definition is from AFR 52-2: "On-the-Job Training is that planned training program designed to qualify a person, through supervised instruction, in the performance of the duties of a given AFS (or MOS for SCARWAF personnel) while he is working in a duty assignment of the career field ladder. The training is not on-the-job training unless the airman spends a portion of his time in a productive capacity on the job." This definition, in a few words, sums up the overall mission of the Air Force on-the-job training program.

You must keep certain principles in mind in order to get the most out of this program. Some of these principles are:

> Air Force training will never end, therefore, on-the-job training will always be required.
>
> Training is <u>your</u> business, <u>my</u> business, <u>everybody's</u> business.
>
> Your unit mission is paramount. However, your unit mission stands a much better chance of being accomplished efficiently if training is given its proper importance.
>
> A training program must include the trainer as well as the trainee.
>
> You cannot apply rigid formulas to different people, different types of training, or different levels of training. A successful program must be flexible.

Flexibility in this sense means that you must be prepared to use combinations of training methods depending on the nature of the subject, time available, and the capabilities of the trainee. The following methods of training are basic to any well-planned unit training program:

DIRECT SUPERVISION (Apprentice or coach-pupil). No other method of training is as effective as intelligent, interested, coach-pupil instruction. In addition to being the quickest way of fitting a new worker into the operation of a unit, it serves as one of the best methods of training. Without specific directions and guidance in learning to perform the necessary duties, a worker is likely to waste time and material, and form bad habits of work.

Many organizations in industry have apprenticeship courses which are designed to train workers in a trade or skill. Their training consists of coach-pupil supervision under skilled workers with periodic group instruction when it is advantageous.

SELF-STUDY. Skilled and semi-skilled jobs require a considerable amount of job knowledge and judgment ability. Even in simple jobs there is much basic job information that the worker must acquire. The more complicated

technical jobs involve both basic and highly specialized technical knowledges and related skills, which must be taught. In skilled jobs, the training given through direct supervision is seldom complete within itself in developing basic airmen into skilled workers. In such cases, formal technical training courses should be utilized to the fullest extent. Workers who come to the job with a fair technical background and some experience can acquire much of the needed job knowledge information through self-study and other self-improvement methods.

GROUP INSTRUCTION is a practical adjunct to direct supervision and self-study. It is a time saver when several workers are to be instructed in the same job knowledges or procedures. It provides opportunity for frank discussions and group problem-solving. It develops good judgment characteristics, provides time to motivate the trainee, and leads to better cooperation among the workers. It affords an opportunity for the supervisor or trainer to check training progress and clarify matters which are difficult for the trainees to understand.

Do not confuse group instruction with classroom or so-called "academic-type" instruction. The two are not the same. Academic-type instruction will certainly hinder production; while group instruction, intelligently used, can expedite production. For example, suppose you have six trainees learning the same job. Four of the trainees are having trouble with a certain job element, while the other two have it "cold." The four men having trouble can be brought over to the other two, and in a short time, the difficulties will probably be solved. In on-the-job training, this is what we mean by group instruction.

Let us now consider the key steps in implementing an on-the-job training program.

Step 1 - Survey unit assignments and insure that each assignment is in the best possible accord with the individual's classification and his specific skills background.

Step 2 - Determine the exact need for training. To determine this need, two things must be established:

a. The specific job requirements.

b. The individual skills of the trainee.

When a and b are known, the on-the-job training required can be stated in a simple formula:

a - b = c (on-the-job training required)

Step 3 - Determine the method or methods of training which will be most effective. Number of people, time available, facilities required, nature of training, and individual capabilities are factors which will affect this decision.

Step 4 - Select the people who will actually conduct the training, remembering that the end product will be no better than those who conduct the program.

Step 5 - Procure all available materials which may be helpful (such as this packaged course) to supplement the program.

Step 6 - Follow-up. This should be a continuous monitoring job to insure that the program does not lag, that training records are kept current, and that proper utilization of newly-developed skills is being made.

This is truly a large order. But now, more than ever before, our Air Force is dependent upon quality training. It is an important job and it is one that never ends.

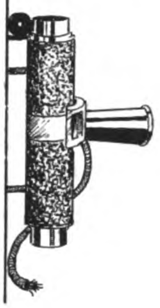
## NOTE TO THE SUPERVISOR

This manual contains review material which will allow the student and the supervisor to make easy transitions to the more advanced material. These references are deliberate and necessary to keep the text material on an adequate level for understanding.

Air Force Manual 35-1 delegates the responsibility of carrying out OJT to the immediate supervisor of airmen. To conduct OJT you need to know the following:

1. What skills and knowledge your airmen are required to learn.
2. How to plan OJT.
3. How to teach.
4. Where you can get textbook material.
5. How to make the airman apply what he is learning.
6. How to test the airman.
7. How to record and report training.

Chapter 1 of this manual tells you and the airman what must be learned. The Appendix tells you how to plan OJT and how to train airmen. It also explains testing and tells you how to record and report training. The remaining chapters of this manual are written in textbook form and contain the lesson materials you will need in teaching. At the end of most chapters are tests and applicatory projects which help the airman to know, to explain, to use and thus to learn his lessons. Remember the key purpose of an Air Force is combat effectiveness. Combat effectiveness requires thorough training of every man. Turn at once to the Appendix and learn how to carry out your training responsibilities.



# CHAPTER 1

## RADIOLOGY

What is RADIOLOGY ? Immediately such ideas as - fissionable - thermonuclear - Bikini - Los Alamos may run through your mind. No, radiology is none of these things but it is just as dramatic, just as exciting and just as interesting as these new fields of atomic knowledge. In fact, radiology was one of the earlier keys to our present Atomic Age.

"Radi" means radiation and "ology" means the "study of" or "science of". Radiology, then, is the study or science of radiation. This term is now primarily used with regard to the use of radiation in medicine. Radiology, for the medical airman, is mainly the use of X-rays to discover and treat diseases and injuries in man. It is a science dedicated to helping the sick. It is dedicated to the task of learning the secret functions of the body, and of revealing them so that man can actually see what happens within the body. It is dedicated to finding and destroying those things which kill us from within.

### YOUR PLACE IN THE RADIOLOGY FIELD

You are welcomed into a field which rewards its workers. In radiology you will learn many interesting things. You need not be afraid of the technicalities because they can be mastered by careful study. Radiology rewards curiosity, because the road to knowledge is through curiosity. As you learn you will feel pride in your knowledge of anatomy, physiology, radiation physics and methods of showing the presence of unseen disease. You will become one of the key links in the chain which restores the ill to health. Besides the reward of knowledge and understanding, however, there are other rewards.

### RADIOLOGY.............A GOOD CAREER FIELD

Radiology is a good field. It is one of the primary diagnostic aids in the hospital and its airmen enjoy a valuable semi-professional standing. This standing is

recognized both in the Air Force and the civilian community. Because the radiologist frequently has time only for the interpretation of the X-rays, the technician has the responsibility, in many cases, for producing them. This requires knowledge, maturity and judgment of a professional quality.

X-ray is an outstanding tool, not only in medicine, but in industry and research. After your retirement from the Air Force, the knowledge and training you will have received will open future doors of opportunity. You will be called upon to do many strange things with your knowledge. You will be able to tell police officers if a diamond is real, or a fruit grower facts concerning the condition of his crop. You will, in the future, preserve foods with radiation. You will help to reveal the mysteries of the molecular structure of substances. You will find unseen flaws in the parts of jet engines and because of your training you may save a pilot's life.

In our field of medicine, you will be amazed at the wonders you will encounter. You will operate machines that will show the motion of the heart; you can see the act of swallowing; and you can cut the body into sections without a knife by using X-rays. You will use radioactive isotopes to locate tumors in the eye, find death-dealing blood clots in the veins and check the amount of iodine that is stored in the thyroid gland.

You will meet and work with physicians who respect your knowledge. The clinics, in which you will work, will be clean, warm and pleasant. Educational opportunities will be open to you from service schools, national X-ray societies, meetings and conventions. You can be registered like a nurse or medical laboratory technician. Your pay will usually be high, both in money - and more importantly - in the rich satisfaction you will find in real service to your fellow man. Radiology is a good field.........a field with a future! Let us see now how to reach for the future with the.............

## RADIOLOGY CAREER LADDER

Because the Air Force realizes the need for men to advance, both in skill and maturity, it has designed specific career ladders within each career field.

## YOUR AFSC

Before we go to the ladder, let us review the AFSC. This will be a very important thing to you throughout your career in the Air Force. The AFSC stands for Air Force Specialty Code.

For an example, we will use the AFSC for the Apprentice Radiology Specialist 90330.

As you see, the code has five numbers to it. The "9" indicates a separate and distinct "occupational area" known as the "Special Service." In this area you have the Air Police, Medical and Personnel Services, etc. The "0" tells us that we are in the medical branch or one of the subdivisions of the Special Services occupational area. Whenever you see "90" you will know that it will be a medical AFSC.

Within the medical branch there are twenty different "Career Fields". The third number, the "3", then, is the radiology career field. Again, whenever you see

"903" it will mean the radiology career field of the medical branch.

The fourth number, number "3", describes your skill in the field. There are three levels of skill in the Air Force. The "3" level is an apprentice, the "5" is the specialist, and the "7" is the technician. You can compare these to the apprentice, journeyman and master ratings given in the construction trades.

The last number, "0" is used to show a further subdivision within the radiology career ladder. In the radiology field there is no further subdivision so the number is just "0". Thus, a 90350 is a Medical Radiology Specialist. With these points in mind let us take a look at the radiology career ladder.

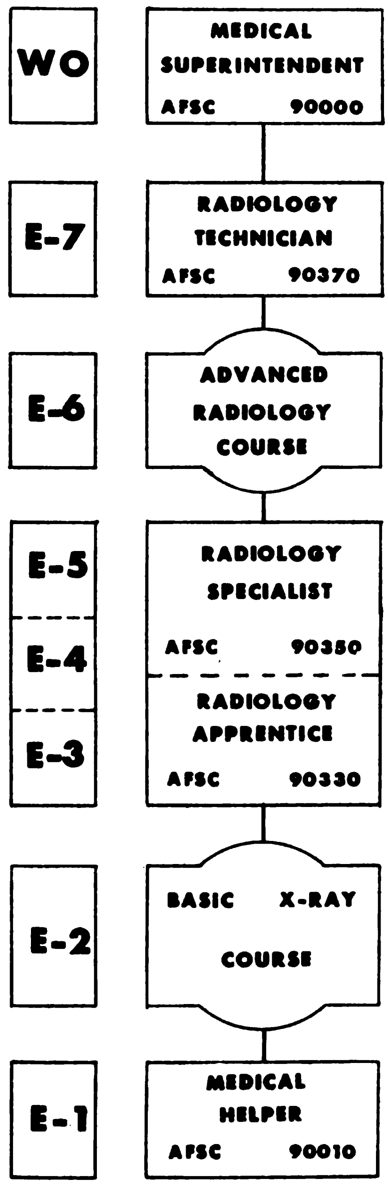



**Figure 1-1 Radiology Career Ladder**

This ladder shows you what positions you must pass through to get to the top. There are five positions on this ladder. They are the medical helper, apprentice radiology specialist, radiology specialist, radiology technician and the medical superintendent.

You should now become interested in the ............

ADVANCEMENT PROCEDURES

When you came into the Air Force you were assigned the AFSC of 00010. This designated you as being a basic trainee. After your selection of the medical career field and completion of training, you arrived at your hospital where you were given AFSC 90010, Medical Helper. This, then, is where you start to climb the ladder.

As a 90010 Medical Helper you have no particular skill in any of twenty career ladders in the medical branch. You want to learn and advance in the radiology career field. What steps must you take to reach the top? From 90010, Medical Helper you must go to 90330, Apprentice Radiology Specialist. The first thing to be done is to place you on OJT. OJT means On-the-Job Training. This training will be given to you by the radiology technician or the radiology specialist. He will teach you as you work. You will be required to spend from sixty to ninety days in this training.

When this training period is over and your supervisor feels you are prepared, he will recommend that you take the Radiology AFJKT. The AFJKT means the Air Force Job Knowledge Tests. If you successfully pass this test, the supervisor will recommend that you be "upgraded" to 90330, Apprentice Radiology Specialist. With this AFSC you can be promoted to airman second class.

From 90330, Apprentice Radiology Specialist you must go to 90350, Radiology Specialist. With this AFSC you can advance to airman first class and staff sergeant. Again, you will be placed on OJT. Your work will increase in responsibility and you will be performing more complex examinations in your department. You will work again for a period of sixty to ninety days. If your work shows that you have learned the skills required of a 5 level technician, your supervisor will recommend that you be upgraded again. However, before you can be awarded the 5 skill level, you must take and pass the 90350 APT. The APT is the Airmen Proficiency Test. This test is given to all airmen going from 90330 to 90350. You can take this test at any time during your OJT training, but generally this is done at the end of such training.

This test is given periodically through the year. To take this test you must have held your 90330 AFSC as a "primary" for at least sixty days. You can also take the test if you have been assigned a "duty" AFSC of 90350 for a period of sixty days. (Reference for this is found in AFM 35-8).

This test has three scoring categories. Category "A" will mean that you are fully qualified to perform the duties of a 90350 as far as knowledge is concerned. Category "B" means that you are on the borderline and must either retake the test or meet a classification board to get the 90350 AFSC. Category "C" makes you unqualified for the AFSC and you must retake the test.

If you take the test and find that you are in Category "C" you will retake the test. In the event that you fail the second time, you will be required to meet a classi-

fication board who will determine whether you can progress in the radiology career field or whether it would be better for you to retrain in some other field. You will not be able to retake the test a third time unless the classification board feels it is the best course of action.

Assuming, now, that you have successfully gained your 90350 AFSC, where do we go from here?

Your next step is 90370, Radiology Technician. OJT, once again, is your course of action. This, too, is for a period of sixty to ninety days. Upon completion of your OJT, you must take your 7 level APT. Here, however, to take the test, you must have held your 90350 AFSC as a primary AFSC or the 90370 as a "duty" AFSC for ninety days. With the 90370 AFSC you are eligibile for advancement to technical sergeant and to master sergeant.

The end of the ladder is the 90000 Medical Superintendent. This is the warrant officer. There are four grades in which you can advance. The top grades receive pay equivalent to the field grade officer rank of major.

To become a warrant officer you must have passed your 7 level APT, the warrant officer supervisory test, and have been a master sergeant for a period of at least one year prior to announcement of the application period. As a master sergeant you cannot exceed forty-two years of age nor have more than twenty-six years of service at the time of your appointment.

There is your ladder. Do you know now what you have to do to climb it? Good luck!

## YOUR DUTIES IN RADIOLOGY

Just what kind of work will you be doing in radiology?

First, as you know, you will be placed on OJT. The jobs that you will be doing are given in what is known as a Job Training Standard. This standard is found at the end of this chapter. In this standard you will find a series of general job areas within the radiology field. Under each job area you will find the job elements or the more exact parts of these jobs. An example of this is the general area of the dark-room. If you will look at that area you will see where there is the element "Loads and unloads film holders and hangs film properly in film hangers". This means then that you will be learning and doing this job. This still is somewhat general because there are many types of film, film holders and hangers. You will learn to know and use each kind.

To the right of these elements you will notice three columns. The columns have a number after each job element under each skill level. This number tells you how well you have to know that job element before you can qualify for the 3, 5, and 7 level. This is a code number and is explained to you at the beginning of your Job Training Standard.

To learn, then, is your first duty!

While you are training for your apprentice skill level you will be doing things

like developing X-rays, setting up machines and tables for simple X-ray exposures and positioning patients for hand and arm X-rays. You will take care of the receptionist desk where you will answer the telephone, check and write down the names of patients who come in for X-rays, match films with request forms and file these films.

Later on as you become an apprentice you will begin to do more of the routine examinations, operate the more complex equipment, do a few special procedures with your OJT trainer and practice good radiation protection. All during this time, you must continue to learn. It is important to you! It is important to radiology!

The specialist and technician duties are to be found in the 90350 and 90370 job description. You will find these in AFM 35-1. Read these to see what you will be doing at these levels (Figure 1-2).

1 July 1964 (Revised)

AFM 35-1
AFSC 90350
Semiskilled AFSC 90330

AIRMAN AIR FORCE SPECIALTY

**RADIOLOGY SPECIALIST**

**1. SPECIALTY SUMMARY**

Operates fixed and portable X-ray machines to take radiographs and to assist radiologist in treatment of disease.

**2. DUTIES AND RESPONSIBILITIES**

a. *Operates X-ray equipment to take radiographs:* Prepares X-ray machine by adjusting control panel settings such as voltage, amperage, and time of exposure. Places patient in radiographic position for desired radiographic examination. Positions loaded filmholder, adjusts table or cassette changer, attaches cones or cylinders, and alines tube for distance, angle, or position. Exposes film to X-rays according to established factor charts and standardized procedures. Takes more difficult radiographs such as gastrointestinal or gall bladder series under immediate supervision and instruction of radiology technician or radiologist. Removes exposed film and processes it according to standard radiographic darkroom procedures.

b. *Assists radiologists in treatment of disease by radiation therapy:* Operates X-ray machine in accordance with instructions of radiologist. Attaches cones and filters to X-ray tube and sets controls of machine. Places the necessary lead sheeting over area not to be treated. Exposes area to be treated to radiation. Records data pertinent to treatment and keeps record of patient's blood count.

c. *Engages in general radiology activities:* Performs duties such as mixing solutions for film processing, loading and unloading cassettes, preparing barium sulphate solutions, cleaning equipment and clinic, and maintaining files of films and patients processed. Performs daily maintenance of equipment used in activity.

d. *Supervises radiology personnel:* Assigns tasks of elementary nature that furnish prerequisite training required for more advanced technical training. Evaluates work accomplished by assistants and determines progress made. Conducts on-the-job training in techniques of operating equipment used in activity and taking radiographs.

**3. SPECIALTY QUALIFICATIONS**

a. *Education:*

(1) Knowledge of fundamentals of anatomy and physiology; theory of physics and electricity as related to radiology; and techniques of operating X-ray equipment and developing radiographic film, is *mandatory*. Attaining a qualifying score on the APT applicable to the specialty described herein satisfies these mandatory knowledge qualifications.

(2) High school level courses in anatomy, physiology, biology, and chemistry, are desirable.

b. *Experience*. Experience in functions such as operating and maintaining X-ray equipment, taking and developing radiographs, or assisting in treatment of disease by radiation therapy, is *mandatory*.

c. *Training*. Completion of a radiology course is desirable.

d. *Other*. Physical profile serial 222331 is desirable for field or base assignment.

**4. SPECIALTY DATA**

a. *Grade Spread:* Airman second class through staff sergeant.

b. *Source Job* (*D. O. T.*):
X-Ray Technician............. 0-50.04

**Figure 1-2 Job Description**

In some medical organizations you will be called upon to perform in all three levels of the radiology career field skills. You cannot and must not divide each skill level with a line. Overlapping is common and necessary for you to learn and gain essential experience. Airmen in radiology look constantly to gaining new knowledge and responsibility. Now, how do you fit into...........

## THE ORGANIZATION OF THE RADIOLOGY SERVICE

The prime and only reason for the existence of the Air Force is to "protect and defend the United States of America". This, as you know, is a big job. The Air Force has to get the most possible strength out of its weapons and men.

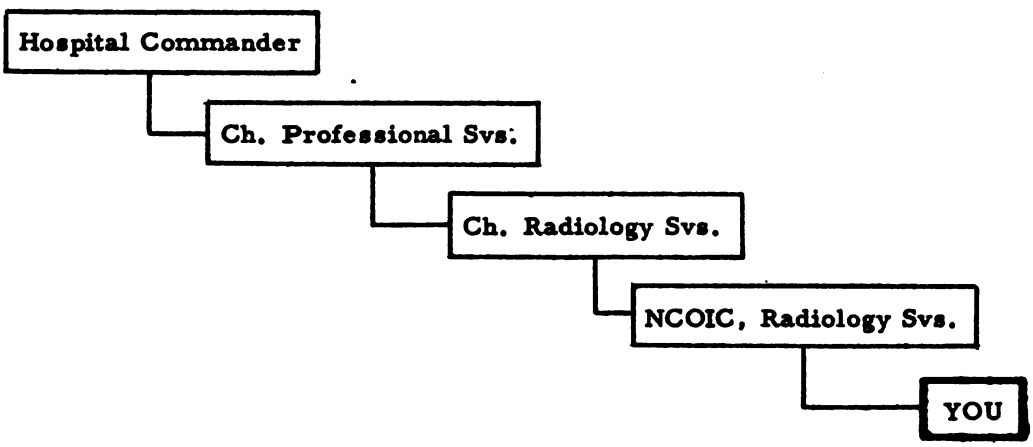
The mission of the Medical Service is to see that these men are kept healthy and capable of working. It is the job of the Medical Service to see that these men are on the job.

The Radiology Service plays a great and vital part of the Medical Service's mission. The Radiology Service's mission is to provide diagnostic aid to the physician and to treat disease with radiation.

To carry out a mission effectively it must have organization. Each department or section in your hospital must know what is to be done and who is to do it. This organization is shown at all levels by what is known as organizational charts. These charts are a series of blocks and lines which show each separate service in your hospital. The lines show you the "chain of command".

You are part of this organization. Let us build an organizational chart and find your place on it. At the top of your hospital organization is the commander. This commander is responsible for the entire hospital. Beneath the commander is the director, professional services. He is responsible to the commander for all of the professional services in the hospital. These services include laboratory, surgical, aeromedical, medical, nursing, out-patient and radiology.

### YOUR CHAIN OF COMMAND



The chief, radiology service, is then responsible to the chief of professional services. The chief of radiology is either a radiologist or a physician experienced in interpreting X-rays. He is responsible for supervising the radiology department. Directly beneath the chief, radiology services is the NCOIC. It is his duty to see that the department carries out its work.

You are responsible to the NCOIC.

## YOUR MISSION ......... AND THE TEAM

You, too, have a mission. You are also a very big part of the team......the radiology team, the Medical Service team and the Air Force team. Your mission is to learn and apply all you can to your field. Your field wants you and needs you..... but it needs the best. Pride in your work and confidence in your knowledge will give satisfaction and advancement both to you and the Air Force.

## OJT PROGRAM OUTLINE AND TRAINING STANDARD

| | |
|---|---|
| Apprentice Radiology Specialist | AFSC 90330 |
| Radiology Specialist | AFSC 90350 |
| Radiology Technician | AFSC 90370 |

## SECTION I - EXPLANATION

PURPOSE OF STANDARD:

1. To indicate the job elements and functional knowledge which are necessary for an airman to perform in AFSC 90330, AFSC 90350 and AFSC 90370 (Column I, Section II).

2. To show the minimum skill level recommended for qualification to AFSC 90330 (Column 2, Section II).

3. To show the minimum skill level recommended for qualification to AFSC 90350 (Column 3, Section II).

4. To show the minimum skill level recommended for qualification to AFSC 90370 (Column 4, Section II).

5. To form the basis on which supervisors can plan and conduct individual OJT programs.

DESCRIPTION OF RESIDENT COURSE:

A sixteen week course is given at USAF School of Aviation Medicine, Gunter AFB, Alabama. It is designed to qualify selected airmen for duties in the Radiology Career Field. Instruction covers methods and practice of operating all types of radiography equipment. To take routine radiographs and to assist the Radiologist in fluoroscopic examinations and radiation therapy treatments. Graduates of this course are awarded AFSC 90330.

EXPLANATION OF CODING

The numbers appearing in columns 2, 3, and 4 are based on the following code key. The code numbers following each job element in columns 2, 3, and 4 indicate the recommended skill levels to be attained in an OJT program for qualification to the apprentice, specialist, and technician levels.

CODE KEY

0. No experience or training on this item.

1. Has only a limited knowledge or this subject or task. Has not actually used the information. Cannot be expected to perform the task.

2. Has received a complete briefing on the subject or task but can use the knowledge or skill only if assisted in every step of the operation. Requires much more training and experience.

3. Understands the subject or task to be done. Has applied part of the knowledge either on the actual job or on a trainer. Can do the job if closely supervised in the more difficult parts.

4. Understands the subject or task to be done and has done the job enough times to make sure he can do it. Needs more practice under limited supervision.

5. Has a complete understanding of the subject or task. Can do the task completely and accurately without supervision.

6. Has a complete understanding of the subject or task, can do the task completely and accurately without supervision, and can apply the techniques and skills to similar equipment or situations.

## SECTION II

## PROFICIENCY LEVEL AND PROGRESS RECORD

| (1) Required Knowledge or Task | (2) App (3) Lvl | (3) Sk (5) Lvl | (4) Sup (7) Lvl |
|---|---|---|---|
| 1. RADIOLOGY CAREER FIELD - AFM 35-1 | | | |
| a. Is familiar with the Radiology Career Field | 3 | 5 | 6 |
| b. Understands progression steps in Radiology Career Field | 3 | 6 | 6 |
| c. Understands the duties of the airmen in Radiology | 3 | 6 | 6 |
| d. Understands the organization of the Radiology Service | 3 | 6 | 6 |
| 2. HISTORY AND PHYSICS OF X-RAY | | | |
| a. Is familiar with the history of X-ray | 3 | 5 | 6 |
| b. Understands the nature of X-ray | 2 | 5 | 5 |
| c. Understands the principles of electricity | 3 | 5 | 5 |
| d. Understands the basic structures and functions of the X-ray machine | 3 | 5 | 6 |
| e. Understands the structure, capacity and types of X-ray tubes | 4 | 5 | 6 |
| 3. ELECTRICAL & RADIATION HAZARDS & PROTECTION | | | |
| a. Understands the hazards that exist in Radiology | 4 | 6 | 6 |
| b. Understands the permissible "r" dosage | 5 | 6 | 6 |
| c. Protects himself and others from existing hazards | 5 | 6 | 6 |
| d. Understands the methods and importance of radiation detection | 5 | 6 | 6 |
| 4. ANATOMY AND PHYSIOLOGY | | | |
| a. Has a good working knowledge of anatomical and medical terms | 4 | 5 | 6 |
| b. Knows the names of the bones of the body and the various structures of these bones | 4 | 5 | 6 |
| c. Knows where each bone of the body is located | 4 | 5 | 6 |
| d. Knows the systems of the body, the organs making up that system and the location and physiology of these organs | 4 | 5 | 6 |
| e. Knows and uses planes, lines and landmarks to locate organs and bones of the body | 4 | 5 | 6 |
| 5. NURSING PROCEDURES IN RADIOLOGY | | | |
| a. Handles sick and injured patients | 3 | 5 | 6 |
| b. Knows and performs isolation, clean and sterile techniques | 3 | 5 | 6 |

| (1) | (2) | (3) | (4) |
|---|---|---|---|
| c. Knows emergency procedures | 3 | 5 | 6 |
| d. Maintains a clean and orderly working area, equipment and department | 5 | 5 | 6 |
| 6. RADIOGRAPHIC TECHNIQUE | | | |
| a. Knows what KVP, MAS and distance are and how they are used | 4 | 5 | 6 |
| b. Knows what detail, contrast, distortion, density and magnification are and how each is related to the Four Prime Factors | 4 | 5 | 6 |
| c. Knows exposure mathematics and can use them in computing exposures | 4 | 5 | 6 |
| d. Understands the types of holders, film and intensifying screens used in radiology and how to use and maintain them | 4 | 5 | 6 |
| e. Knows and understands what cones, cylinders, diaphragms, grids, buckys, filters and spot film devices are, and can use them properly in examinations | 4 | 5 | 6 |
| f. Knows and applies the various types of exposure charts | 4 | 5 | 6 |
| g. Familiar with effects pathology has on exposure factors | 2 | 4 | 6 |
| h. Adjusts control panel and table for exposures | 4 | 5 | 6 |
| 7. RADIOGRAPHIC POSITIONING | | | |
| a. Prepares and instructs the patient on the things he is to do during an examination | 4 | 5 | 6 |
| b. Prepares and places on films all information necessary to identify patient, side, special procedures, times of examination, etc. | 4 | 5 | 6 |
| c. Uses positioning devices and immobilization aids needed in the examinations | 4 | 5 | 6 |
| d. Positions the patient, film and tube in proper alignment for routine exposures | 4 | 5 | 6 |
| 8. DARKROOM PROCEDURES | | | |
| a. Operates darkroom equipment | 4 | 6 | 6 |
| b. Prepares film processing solutions | 5 | 6 | 6 |
| c. Loads and unloads film holders and hangs film properly in film hangers | 5 | 6 | 6 |
| d. Processes film through the developer, rinse, fixer, wash and dryer | 5 | 6 | 6 |
| e. Knows the cause and prevention of the more common artifacts caused by improper darkroom procedures | 3 | 5 | 6 |
| f. Understands special processing procedures and film identification | 3 | 5 | 6 |
| g. Keeps darkroom and darkroom equipment clean and orderly | 5 | 6 | 6 |

| (1) | (2) | (3) | (4) |
|---|---|---|---|
| 9. SPECIAL TECHNIQUES AND PROCEDURES | | | |
| a. Understands the purpose, technique, positioning, contrast media, special precautions and equipment needed for the standardized special procedures | | | |
| (1) Digestive System | 3 | 5 | 6 |
| *(2) Circulatory System | 1 | 3 | 5 |
| (3) Respiratory System | 1 | 3 | 5 |
| (4) Urinary System | 3 | 5 | 6 |
| *(5) Nervous System | 1 | 3 | 5 |
| *(6) Genital System | 1 | 3 | 5 |
| b. Understands the purpose, technique, positioning, special precautions, and equipment used in special techniques | | | |
| *(1) Foreign Body Location | 2 | 3 | 4 |
| (2) Stereoscopy | 4 | 5 | 6 |
| (3) Pelvimetry | 4 | 5 | 6 |
| *(4) Photoflourography | 4 | 5 | 6 |
| 10. *RADIATION THERAPY | | | |
| a. Understands the theory and principles of radiation therapy | 2 | 3 | 4 |
| b. Knows how to prepare patients for treatment | 2 | 4 | 5 |
| c. Knows how to set up the therapy unit, use auxillary equipment and adjust control panel and tube | 2 | 4 | 5 |
| d. Maintains therapy records | 2 | 4 | 5 |
| 11. FIELD AND PORTABLE EQUIPMENT | | | |
| *a. Field X-ray Equipment | | | |
| (1) Can assemble, disassemble, and operate field equipment | 4 | 5 | 6 |
| (2) Understands the more common breakdowns of field equipment and their correction | 3 | 5 | 6 |
| b. Portable X-ray Equipment | | | |
| (1) Operates portable unit | 4 | 5 | 6 |
| (2) Develops positioning and exposure techniques in a bedside situation | 4 | 5 | 6 |

NOTE:
* Elements, functions or knowledge so marked are not required for completion of the OJT program, unless equipment required is available in the section.
The On-the-Job Trainee, should, however, become familiar with the information given in this OJT manual.

| (1) | (2) | (3) | (4) |
|---|---|---|---|
| 12. EQUIPMENT MAINTENANCE | | | |
| a. Analyzes minor malfunctions | 3 | 5 | 6 |
| b. Performs first echelon maintenance within permissible limits | 2 | 5 | 6 |
| c. Knows how and does obtain maintenance and repairs on radiographic equipment by using supply procedures | 4 | 5 | 6 |
| 13. RADIOLOGY DEPARTMENT ADMINISTRATION | | | |
| a. Understands and observes proper medical X-ray ethics | 5 | 6 | 6 |
| b. Performs receptionist duties such as answering telephone; maintaining daily patient logs, appointment schedules, correspondence and report files, nominal index files and film files | 4 | 6 | 6 |
| c. Disposes of films and records | 4 | 5 | 6 |
| d. Is familiar with department correspondence | 4 | 5 | 6 |
| e. Understands and applies the supply procedures related to the radiology department | 4 | 5 | 6 |
| f. Prepares reports, work schedule, duty rosters and personnel actions required in a radiology department | 4 | 5 | 6 |
| 14. SUPERVISION | | | |
| a. Supervises Radiology personnel | 2 | 4 | 6 |
| b. Plans and schedules department work load | 2 | 4 | 6 |
| c. Evaluates work of subordinate personnel and recommends classification and promotion | 2 | 4 | 6 |
| d. Checks all work produced in the department for accuracy and workmanship | 2 | 4 | 6 |
| e. Uses management and leadership principles in utilizing department personnel properly and in settling personal differences | 2 | 4 | 6 |
| 15. TRAINING | | | |
| a. Determines the status of training of subordinates | 2 | 4 | 6 |
| b. Plans OJT programs | 2 | 4 | 6 |
| c. Conducts and supervises OJT program established in department | 2 | 4 | 6 |
| d. Maintains training records | 2 | 4 | 6 |
| 16. MEDICAL SERVICE TEAM | | | |
| a. Understands responsibilities as a medical team member | 5 | 5 | 5 |
| b. Participates as a trained member of medical service teams in emergency duties | | | |
| (1) Cares for patients | 4 | 4 | 5 |
| (2) Carries out first aid | 4 | 4 | 5 |
| (3) Performs assigned duties during emergencies | 4 | 4 | 5 |

## STUDY QUESTIONS

1. What does the word "radiology" mean?
2. What is radiology dedicated to doing?
3. Why is radiology a good field to enter?
4. What does AFSC mean?
5. How many numbers are there in the AFSC?
6. What does the "9" indicate in the radiology AFSC?
7. What does the "90" mean to you?
8. What does "903" mean to you?
9. What does the fourth number of the AFSC designate?
10. How many skill levels are there in the Air Force?
11. What does the last number of an AFSC indicate?
12. How many positions are there in the radiology career ladder?
13. In order, what are these positions?
14. What AFSC did you have in basic training?
15. What does a 90010 AFSC mean?
16. What is the AFSC for the apprentice radiology specialist?
17. What is the first thing you have to do in gaining a new AFSC?
18. How long are you required to spend on OJT when going from 90010 to 90330?
19. What does AFJKT mean?
20. What is the AFSC of a radiology specialist?
21. To what grade can you be promoted if you are carrying a 90350 AFSC?
22. How long do you have to OJT to get a 90350 AFSC?
23. Before you can receive your 90350 AFSC, what test must you take?
24. When are you eligible to take this test?
25. How many times a year is this test given?
26. How long must you hold a 90330 AFSC as a "primary" before you are eligible

to take the 90350 test?

27. How long must you hold a "duty" 90350 AFSC before you are eligible to take the test?

28. If you take the test and are in Category "B", what must you do to get a 90350 AFSC?

29. What does it mean if you take the test and are scored in Category "C"?

30. What position follows the radiology specialist position?

31. How long must you OJT to get a 90370 AFSC?

32. How long must you hold a primary 90350 AFSC before you are eligible to take the 7 level test?

33. Which grades can you be promoted to if you hold a 90370 AFSC?

34. Which AFSC is held by a medical superintendent?

35. To become a medical superintendent, what two tests must you pass?

36. What is a job training standard?

37. What is a job element?

38. What is your first duty when you enter the radiology career field?

39. Name some of the things that you will be doing as you are training to the apprentice level?

40. What will you find in the 90350 and 90370 job descriptions?

41. Where can you find these job descriptions?

42. What is the mission of the Air Force?

43. What is the mission of the Medical Service?

44. What is the mission of the radiology service?

45. What is an organizational chart?

46. How do you know what the "chain of command" is in an organization?

47. Who is responsible to the hospital commander?

48. Who is the chief of radiology services responsible to?

49. Who are you responsible to?

50. What is your mission in the radiology field?

51. What three teams do you belong to now?

## WORK PROJECTS

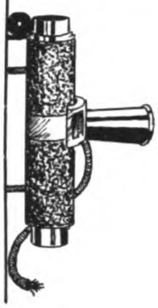
1. Go to your personnel section and ask the sergeant major or the first sergeant to let you see AFM 35-1. Read the job descriptions for the 90350 Radiology Specialist and the 90370 Radiology Technician.

2. Ask your OJT supervisor to explain to you the instances when an airman first class can hold a 90370 AFSC.

3. Draw an organizational chart of your hospital radiology department. Place both the positions and the names on the chart. Include your position.

4. If you are near a population center, contact some of the radiology departments in the civilian hospitals and find out if there is an active X-ray Society organized in the community.

5. Have your OJT supervisor go over the local policies on classification and promotion with you.



# CHAPTER 2

## PHYSICS

In this chapter you will study the basic subjects that will make you a good technician. Many airmen become fearful when they look over this technical material. While the contents may appear difficult, most airmen learn them easily. After you read, study and talk this chapter out with your supervisor you will find that you can readily understand it.

This chapter will give you the background for a scientific understanding of what you are doing. Do not go over it lightly. Your house of X-ray knowledge will need to be placed on a firm foundation of scientific learning. This chapter is your foundation.

WHAT IS IN THIS CHAPTER? This chapter contains the history and the physics of X-ray. This history will give you the story of the discovery and development of X-rays. X-ray physics tells the what, the why and the how of X-rays. You will learn about the atom, principles of electricity, the X-ray machine and tubes. Any good technician must know his tools and how they can best work for him. In this chapter you will learn your tools and how they operate.

HOW DO YOU STUDY? There is a right and wrong way to learn scientific subjects. Work always for understanding - not for memorization. Memorized material is quickly forgotten. Scientific lessons that are thoroughly understood are long remembered. First, skim through the chapter and look at the subtitles. This will give you an idea of what you will be studying. Next, read each paragraph as carefully as you can. After you read the paragraph, stop a minute and recite to yourself some of the things that you have just read. If possible, talk them over with others. After you have skimmed, read and recited, ask yourself some questions.

What was the paragraph about? What specific things were in the paragraph? Do I know what an atom is? Do I know what it is composed of? Ask yourself who, what, when, where, why and how? If the answers are not clear to you, return to the material and read it once again.

QUESTIONS. Be sure to use the questions in the back of each chapter. If you can answer these well you will KNOW the material. Also perform all the work projects. Reading is necessary for learning, but DOING is just as essential.

# HISTORY OF X-RAYS

BACKGROUND. The history of X-ray began with the discovery, by the Chinese, of the lodestone. This discovery started man on the quest for knowledge of electricity and magnetism and this knowledge led to scientific progress which ultimately resulted in the discovery of X-rays. Men such as Guericke and Boyle worked on vacuum pumps. Newton, Gray and van Mussenbroek worked with electricity and discovered the principles of electrostatics. Our own Franklin gave us the "positive" and "negative" that we know today. There were the discoveries of Galvani, Volta and Oersted who worked with batteries and disclosed the link between electricity and magnetism. Ohm gave to us the laws of relationship between current, voltage and resistance. Hittorf and Crookes worked with gases in vacuum tubes and revealed the cathode ray. These men and their work were essential to the discovery of X-ray.

DISCOVERY. While working with a Crookes tube, November 8, 1895, Professor Wilhelm Conrad Roentgen, a physics professor of Germany's University of Wurzburg, discovered a new invisible ray. He had been making experiments in his laboratory to reveal the nature of cathode rays and what effect these rays would produce. These experiments were connected with the problem of passing high tension currents through a tube and deflecting the rays from a straight path by magnets. This meant that cathode rays had an electrical charge of some kind. These rays would also cause fluorescence of the glass at the end of the tube. It was this fluorescence that interested Roentgen. On the day of the discovery of X-rays he had covered the tube with black paper which would screen out the cathode ray. When he connected the terminals of his apparatus he noticed a strange phenomenon. Although the tube was completely covered with black paper, he saw a fluorescent glow on the barium plantinocyanide screen across the room. He quickly realized that he had seen an effect of a completely new type of invisible ray. Though this ray must have been produced before by others working with the Crookes tube he was the first to see the effect of X-ray. He named the ray the "X" ray. "X" was for unknown.

In the few weeks that followed his discovery, Roentgen experimented with the ray so thoroughly that little could be added to his work until years later. The property of the ray, which could cause exposure of a photographic plate, and his first X-ray of his wife's hand revealed the amazing possibilities to the medical field. Because of his work and discovery, Roentgen was awarded the Nobel Prize for physics in 1901.

Immediately after his findings had been published, work was begun by countless other people to put the new knowledge to work. The medical profession was one of these groups. At first, practical application was difficult. The equipment was poor and it sometimes required a physicist to make an exposure. Progress was impaired when people began to complain that they had undesirable physical reactions from the new ray.

## MILITARY ROLE IN ADVANCING X-RAY

One must realize that at first the X-ray machine was but a toy to most. However, a few men continued to work and develop machines which were forerunners to our present day equipment and techniques. In World War I the use of X-rays began to take on real importance. The military physicians who were highly concerned with

bullet wounds and fractures began to realize the great value of X-rays in diagnosis, and the first school that specialized in radiology instruction was set up by the Army at Camp Greenleaf near Chattanooga, Tennessee.

THE HOT CATHODE TUBE. Prior to the invention of the "hot cathode tube" X-ray tubes had been filled with gas. These gas tubes were highly unsatisfactory. W. D. Coolidge of General Electric Company experimented with a hot cathode tube and developed the principle which later was to be generally applied in common X-ray practice. Coolidge supplied a number of other inventions that provided the basis for much of our modern day equipment.

THE FUTURE OF X-RAY. The work of these brilliant pioneers led to the present day use of X-ray as a great applied science. Progress in the use of X-ray continues and it has a tremendous possibility for future development. The discovery and the advancement of X-ray has given man longer life and its future progress will add even more years to his life. As you work with the highly trained and inventive doctors of the USAF Medical Service, you may help make additional history in X-ray.

Turn yourself now to the task at hand and begin to learn what you should know about.....................

## X-RAY PHYSICS

Where does one start to learn X-ray physics? Because you are dealing with radiation you must encounter the term "matter" and the term "energy". These two things have a great deal to do with your understanding of radiation. You will start with................

### MATTER

Matter is anything that has weight and occupies space. Think of this and repeat it to yourself. Look about you now. You see matter as a chair, a pencil or a piece of paper. Each of these things has some weight and occupies a certain space. All of them have length, width and depth. Because of their three dimensions they have a volume that you can measure. If you took the chair you are looking at and compressed it into a square lump you can see that it would still be matter. It would occupy space and have a specific weight. Keep this concept of matter in your mind as you study.

### ENERGY

Energy is the ability of a piece of matter to do work. In thinking of this you have to think in slightly different terms than you have used before. WORK, in the sentence above, is the amount of FORCE necessary to move one object from one position to another position. If you put your finger at the end of your pencil and shoved the pencil across the table you have done work. This work required energy. The energy that shoved the pencil came from your muscles. Your finger and muscles are matter.

## FORMS OF ENERGY

There are different forms of energy. Bodies that are in MOTION are said to have KINETIC energy. Bodies at rest are said to have POTENTIAL energy. Bodies that possess potential energy produce kinetic energy when they are moved. In moving there is a loss of energy. The process of moving uses this energy. Besides kinetic and potential energy there are also other forms of energy. Among these are heat, radiant energy like the light from the sun, and also electrical energy. In the production of X-rays you will use all of these types of energy. We will need to know the source of all these types of energy which is ................

## THE ATOM

WHAT ARE ATOMS? Because you will be using atoms to produce X-rays you will have to know something about them. You will not be required to know everything about the atom, but you probably will have to learn more of its nature than you now know.

The atom is the smallest particle of an element. An element is a basic substance like gold, oxygen, sulfur or uranium, which cannot be broken up by ordinary heat or electrical energy. All elements are composed of atoms.

Atoms are matter. Atoms have weight and they occupy space. The weight and the space that they occupy is very small. Two billion atoms could sit on the head of a pin.

Atoms have energy. It takes energy to hold their parts together. When an atom is broken up it releases energy. You will not break up the atom in X-ray, but you will use some of its energy and some of its parts.

PARTICLES OF ATOMS. The atom, as far as you are concerned, is made up of three parts: the PROTON, ELECTRON, AND NEUTRON (Figure 2-1).

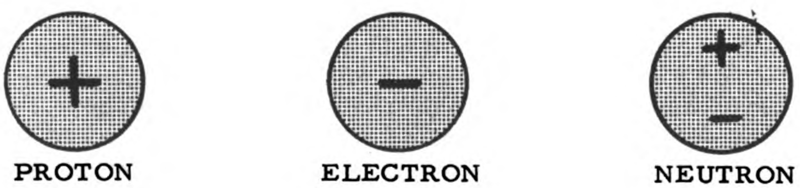



Figure 2-1 Particles of Atom

The proton is a positively charged particle in the atom. The electron is the negatively charged particle in the atom. The neutron is a particle in the atom which has no charge. This charge we are talking about is the type of attraction or pull that these particles have for each other.

WHAT ATOMS LOOK LIKE. Now that you know that the atom has a proton, an

electron and a neutron, what do these atoms look like? You know what a marble looks like. Picture the atom in your mind as being round like a marble. You will take this marble and divide it into three smaller marbles. Then you will draw a circle. You will take the three little marbles and paint one red and call it a proton. The second marble you will paint blue and call it a neutron. You will put the red proton and the blue neutron real close together so they stick to one another and place them in the center of your circle. What you have made is to be called the NUCLEUS OF THE ATOM. The nucleus of an atom is made up, then, of a red proton and a blue neutron. The last marble you will paint green. You will call this marble an electron and put it in the line that you drew to make the circle. This line of the circle is to be called the ORBIT of the atom. The green electron, then fits in the orbit of an atom.

Now let us show the green electron so that it moves around the circle line we have drawn. Round and round it goes about the red proton and the blue neutron or the nucleus. This is how an atom looks (Figure 2-2).

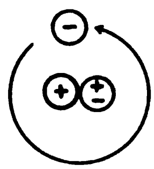


Figure 2-2 An Atom

WHAT HOLDS THE ATOM TOGETHER? In looking at your atom you see the nucleus and the orbit. In X-ray and radioactivity you are interested in finding out more about them. What is it that makes the electron go around the nucleus without trailing off? Why don't the electron and proton get closer together? If atoms make up elements, what kind of atom is in each different element?

An electron is the lightest part of the atom. It weighs only 1/1845 as much as the proton, but it has the same amount of electrical charge that the proton has. Remember that the electron has a negative charge. Remember also that the electron is spinning round and round the nucleus. Although the proton has a positive electrical charge the electron gets just so close because the spinning action of the electron, which is kinetic energy, counterbalances the attraction exerted by the proton. In other words, although the proton and electron are strongly attracted toward each other, the electron has enough kinetic energy to overcome complete attraction to the proton. It is a miniature tug of war that ends in a tie. The electron cannot go flying off because it does not have enough kinetic energy to completely overcome the pull of the proton.

ATOMIC NUMBER AND ATOMIC WEIGHT. Now you have answered some of your questions. However, let us see what kinds of atoms make up the different elements. There are different atoms for each element. All of these atoms have protons and electrons. Only one element, hydrogen gas, has no neutron.

The key to the different elements is the NUMBER OF ELECTRONS SURROUNDING THE NUCLEUS. YOU MUST ALSO KNOW THAT FOR EVERY ELECTRON IN THE ORBIT OF THE ATOM THERE IS AN EQUAL NUMBER OF PROTONS IN THE NUCLEUS.

The number of electrons in an atom of an element is the ATOMIC NUMBER of that element. For example:

- Hydrogen has one electron in its orbit. Its atomic number is ONE.
- Uranium has ninety-two electrons in its orbit. Its atomic number is NINETY-TWO.

You should also know about the ATOMIC WEIGHT of an element. This is of importance to you when we explain isotopes and radioactivity to you in the therapy section.

The atomic weight of an element is the NUMBER OF NEUTRONS AND PROTONS IN THE NUCLEUS OF AN ATOM. You can always find the number of neutrons in an atom if you subtract the number of electrons or the atomic number from the atomic weight. Remember that there is an equal number of protons to electrons so what is left must be neutrons. For example:

- Uranium has an atomic weight of 238. Its atomic number is 92. This means that there are 92 electrons in its orbits and also that there are 92 protons in its nucleus. The number of neutrons in an atom of uranium is then 146.

ENERGY LEVELS OF THE ATOM. Return now to the electron and the elements. There are 98 known elements. Because each element has its own atomic number this means that there are atoms with 1 to 98 electrons in their orbits. Because of the number of electrons, an atom must have a number of orbits. In other words, there will be a number of circles around the nucleus and each circle will hold a certain number of electrons. These orbits have been given letter names and are also known as ELECTRON SHELLS. Starting near the nucleus they are K, L, M, N, O, P and Q. (Figure 2-3).

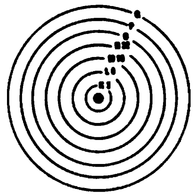


Figure 2-3 Electron Shells

Each one of these shells will only hold so many electrons. The "K" shell will only hold 2 electrons. If an atom has 3 electrons, like lithium, the third electron must take its place in the L orbit or shell. The "L" shell will hold 8 electrons. The "M" shell will only hold 18 electrons. The remaining shells cannot hold any more than 32 electrons each.

Now each of these shells has an ENERGY LEVEL. The closer an electron is to the nucleus the higher the energy level. Think about this for a moment. What this means is that an electron is more tightly held near the nucleus. It would require more energy to remove one of these electrons, say in the "K" shell, than it would for

one in the "Q" shell. Why is this? Because of the pull of the nucleus, those electrons near it are held more strongly. As the distance from the nucleus increases, the force of pull is not as strong. Put yourself in an imaginary situation. You are standing in front of a huge atom. The nucleus of the atom is formed by protons and neutrons as big as basketballs. Around this nucleus, electrons, the size of walnuts, are spinning. If you grab one of the walnuts near the basketballs you will really have a tug to get it away. However, if you select one out in, say the "Q" shell, you can flick it away with your finger.

One more thing about these energy levels.... Each one of these energy levels, except "K", have sub-energy levels. Two of its electrons are closer to the "K" shell than the other. These two sub-energy levels make up the "L" shell. The other shells have a similar arrangement (Figure 2-4).

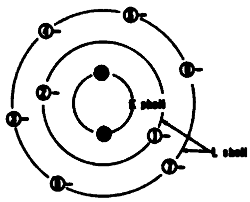


Figure 2-4 Sub-energy Levels

## X-RADIATION

**ELECTROMAGNETIC SPECTRUM.** What are X-rays? X-rays are part of the electromagnetic spectrum. The electromagnetic spectrum is made up of electromagnetic WAVE RADIATIONS. These radiations are rythmic electrical and magnetic impulses which rise to a peak and then fall to a trough. Electromagnetic waves make up the radio waves we hear, the light rays we see, the infra-red rays with which we can take pictures in the dark, ultra-violet rays that we use to treat skin disease and that cause sunburn, the X-RAY WHICH YOU ARE STUDYING, GAMMA RAYS of the atom bomb and the cosmic rays, which at the moment, hinder our travel in space. (Figure 2-5).

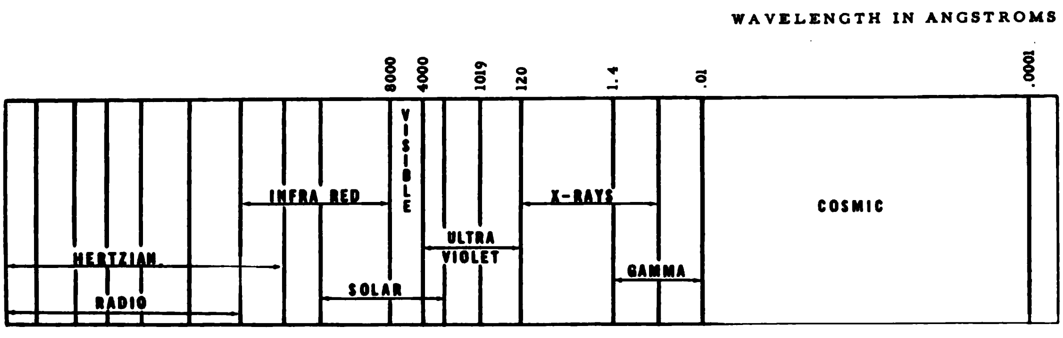



Figure 2-5 Electromagnetic Spectrum

**WAVELENGTHS AND FREQUENCY.** All of these rays or waves travel at the speed of light which is 186,000 miles per second. These rays are recognized by their different WAVELENGTHS. Wavelength is the distance from one peak of the wave to the other peak (Figure 2-6).

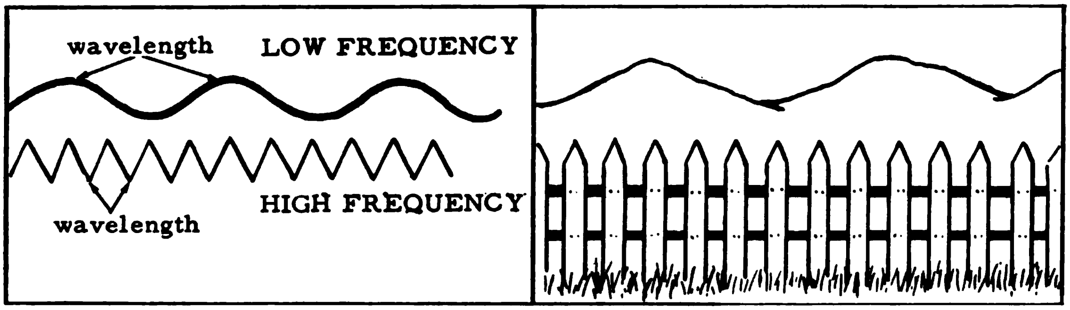



Figure 2-6 Wavelengths and Frequency

Now, although the rays are all traveling at the same rate of speed, some of the rays will rise to their peaks and fall to the troughs faster than other rays. This is known as the FREQUENCY of the wavelength. To imagine this, picture a picket fence and draw a solid line from the bottom of one picket to the top of the next and so on. Now place three rolling hills behind the picket fence and draw a line over their outline. If you remove the fence and hills you will see one line with many peaks and the other with three rolling peaks. These lines would represent the frequency of the wavelengths. We could say that there are more peaks per inch in one wavelength than another. The more peaks per inch the higher is the frequency.

X-ray wavelengths have many different frequencies. This is important for you to understand in X-ray. This frequency will determine whether you have a SHORT or LONG X-ray wavelength. The wavelength DETERMINES HOW FAR AN X-RAY WILL PENETRATE THROUGH A PIECE OF MATERIAL (Figure 2-7).

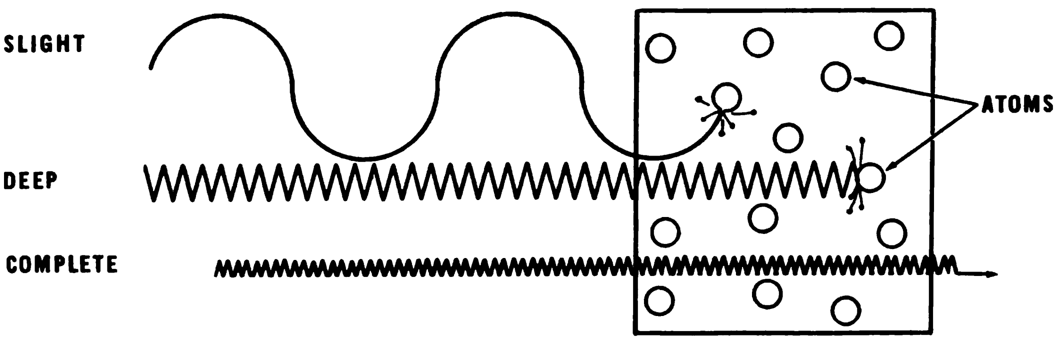



Figure 2-7 Penetration of X-rays

**PHOTONS.** You know now that an X-ray is an electromagnetic wave or ray. This wave or ray, as we said before, is made up of rythmic electrical and magnetic impulses. THESE IMPULSES ARE PURE PACKETS OF ENERGY CALLED PHOTONS. These photons have no weight and do not have an electrical charge. These photons of

energy do not have the same amount of energy. The energy of X-ray photons is dependent upon the FREQUENCY OF THE WAVELENGTH. If you have a low frequency wavelength you will have what is known as a "long" or "soft" X-ray. This long X-ray will not have as much energy or penetrate as far as a high frequency wavelength. A high frequency wavelength is known as "short" or "hard" X-ray. REMEMBER.... THE SHORTER THE WAVELENGTH THE GREATER THE PENETRATION!

X-RAYS. X-rays, then, are weightless packages of pure energy..... photons. They have no electrical charge. They travel at 186,000 miles per second. They penetrate matter. Their energies depend upon the frequency of their wavelengths.

WHAT DO X-RAYS DO? To gain still more understanding of X-rays, it is necessary for you to know a little more of how they act and what they do. You have had some of these things in previous paragraphs but this will be a summary of them.

## HOW X-RAYS ACT

- X-rays are invisible. You cannot see, hear, feel, or smell them.
- X-rays travel in straight lines. They are not deflected when passed through a magnetic field so do not show an electrical charge.
- X-rays travel at the speed of light.
- X-rays have a wide range of wavelengths.
- X-rays cannot be focused to a point.

## WHAT X-RAYS DO

- X-rays expose photographic film.
- X-rays cause fluorescence in certain substances.
- X-rays are absorbed in matter. This absorption depends on the atomic structure of the matter and the wavelength of the X-rays.
- X-rays can ionize gases.
- X-rays can discharge electrically charged bodies.
- X-rays can kill or damage living tissue.
- X-rays can cause changes in chemical substances.

You will learn in later chapters how each one of these properties of X-rays is used by the technician. Each one of these facts is a tool for you to use. Now that you know what X-rays are, how they act and what they can do let's see about the .......

## PRODUCTION OF X-RAYS

X-rays are produced when a stream of negatively charged electrons are shot rapidly across a vacuum and are stopped suddenly by a target made of tungsten metal.

The production of X-rays requires three things. They are:

- A source of "free" electrons.
- A means of putting these electrons into extremely rapid motion.
- A means of stopping these electrons as suddenly as possible.

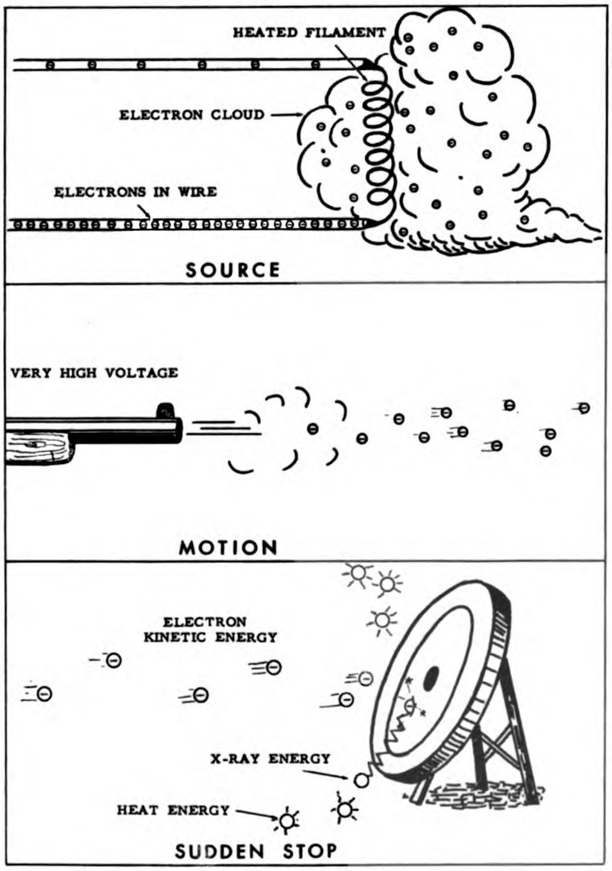



Figure 2-8 Source - Motion - Sudden Stop

**THE SOURCE.** The source of "free" electrons you will use in X-ray will come from a white hot tungsten metal "filament". When this metal is heated to a certain degree, the electrons in the atoms of tungsten gain added kinetic energy. With this added energy they "free" themselves and form sort of a cloud around the tungsten filament. Remember that these electrons are negatively charged. They have enough added energy to free them a little bit from the parent atoms but not enough to go shooting off on their own. You have to find some means of putting them into ..........

**EXTREMELY RAPID MOTION.** This cloud of free electrons is put into rapid motion by a very high electrical voltage. In your home you use only 110 volts to light your house and to run its appliances. In X-ray you will be using from 30,000 to 1,000,000 volts. This very high electrical voltage gives the free electrons a mighty shove. This shove adds still more kinetic energy to the electrons. Remember that a body in motion produces kinectic energy. You must now find a way to .........

**STOP ELECTRONS SUDDENLY.** You stop these madly rushing electrons with a target made of tungsten metal. When these speeding electrons hit this target they are either stopped completely or slowed down a great deal. Whichever happens causes these electrons to lose some of their kinetic energy. They have gained this energy in their motion. If they are stopped or slowed down they cannot use this energy so it has to be converted into something else. REMEMBER THIS! If energy is changed from one kind of energy to another kind of energy, the energy that goes into the change is equal to the energy that comes out. This is quite a mouthful, but read on and you will see what it means.

As the electron hits the target and is stopped or slowed down, its kinetic energy is changed to heat energy and X-RAY PHOTONS. The amount of heat energy and X-ray energy added together would be the same as the kinetic energy.

## SUMMARY

This, then, is how an X-ray is produced. You use electrical energy to produce heat in the filament. This heat produces enough kinetic energy to free the electrons slightly. You apply more electrical energy to produce more kinetic energy in the electrons. You then stop these electrons suddenly and the sudden stop divides their kinetic energy into HEAT ENERGY AND X-RAY ENERGY.

**BEHIND AND AHEAD.** You know now many things. You know the history of X-rays, and you know about matter and energy. You are aware of the atom, its parts and energy levels. You realise what an X-ray is, how it acts and what it can do. You have learned the very basic fundamentals of how X-ray is produced.

But now you go on to learn about electricity and magnetism. This is to help you understand the parts of your X-ray machine that you must use to produce X-rays.

# ELECTRICITY AND MAGNETISM

You can't have one without the other! <u>You can't have X-rays without electricity and magnetism.</u> In this section you will learn the various laws of electricity and magnetism. This is necessary so that you can understand how the various electrical devices work and why they are arranged in a certain order in your X-ray machine. You will learn what lines of force are, about AC and DC current, how a transformer is used and what makes a solenoid work. You will know how and why we have to rectify currents and understand the principles of the various measuring meters.

Do not be afraid of this section. The study of electricity and magnetism can be amazing and interesting if you approach it with an attitude of wanting to get acquainted.

Gaining knowledge is like gaining friends. Be friendly with people and soon you know much about them and they will do all sorts of things for you. Electricity and magnetism are like that. We really don't know what they are, but we know once you get to like them that they will help you in many ways.

You will learn about electricity and magnetism as it affects each device on your machine. The electricity that is coming into your building at this precise moment had to be generated somewhere and transported to your light bulb or X-ray machine. You will begin from the start of that electricity, but first you will learn what an electric current is.

ELECTRIC CURRENT. Electric current is a FLOW OF ELECTRONS THROUGH A METAL WIRE CONDUCTOR. A conductor is material which allows an easy passage of electrons. For current to flow there must be a DIFFERENCE OF POTENTIAL. This means that current will flow from a position of HIGH potential to a position of LOW potential (Figure 2-9).

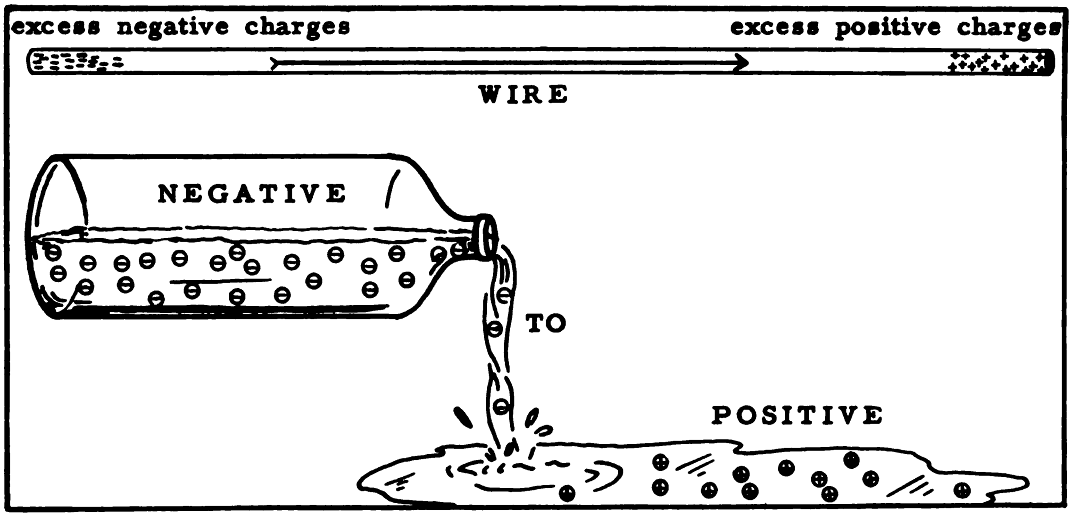



Figure 2-9 Difference of Potential

This term "POTENTIAL" must be understood. Potential is the tendency of a charge to move from one place to another. It is the ability, not the actual doing, of a body to do a certain amount of work. For example, if you took a two-pound rock and placed it three feet off the floor this rock could produce much kinetic energy if it were dropped. We could figure its potential.

In electricity we must think along the same lines. Our potential, however, is dependent upon the inequality of positive and negative charges (electrons) at two points of a wire conductor. In electricity POSITIVE AND NEGATIVE CHARGES ATTRACT EACH OTHER. If there is a high negative potential, or an excess of negative charges, on one end of the wire and a shortage of negative charges on the other end, the excess positive charges would attract them and cause a flow of current. Each positive charge that attracts a negative charge is satisfied. When all the positive charges attract an equal number of negative charges, then no difference exists. You then have a ZERO POTENTIAL. Each charge is neutralized and there would no longer be a flow of electrons or current.

You know now that electrical current is a flow of electrons. You know also that there must be a difference of potential between two points to allow this flow. And you know that current flows from negative to positive.

ELECTRIC CIRCUITS

Before a current can flow it must have a path. This path is known as the circuit. There are three things that are present in any electrical circuit. They are voltage, amperage and resistance (OHMS).

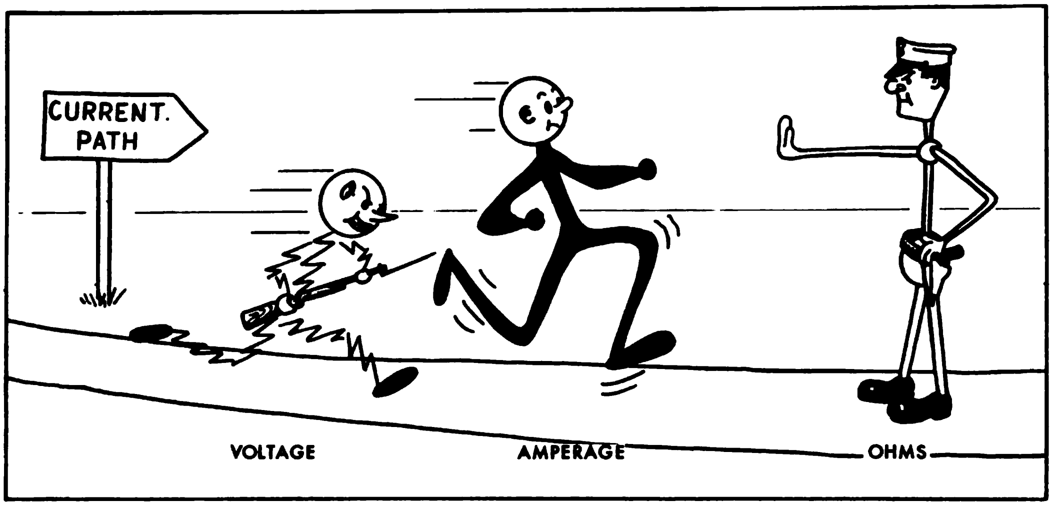



Figure 2-10 Factors of Electric Current

VOLTAGE. Voltage is the force necessary to move the current through the wire of the circuit. It provides the push. Voltage and potential difference can mean the same thing. If you have a voltage of 110 you will also have a potential difference of 110 between two points on a circuit. When voltage pushes current through a conductor there is a gradual weakening of its push until after a certain distance the voltage disappears. The unit of voltage is the VOLT. In X-ray you work with thousands of volts and use the term KILOVOLTS in talking about voltage. 1000 VOLTS MAKE UP 1 KILOVOLT.

AMPERAGE. Amperage is the amount of current or electrons flowing per second past any certain point in the circuit. The more electrons flowing past this point per second the more amperage you will have in the circuit. The unit of measure of this amount of electrons is the ampere. In X-ray you will use one one-thousandth of an ampere; milliampere is one one-thousandth of an ampere. As you can see, you will be using high voltages and very low current.

RESISTANCE. Resistance is present in any circuit. Resistance is the reluctance of the material in the conductor to let a flow of electricity pass through it. The unit of resistance is the OHM. In X-ray we use this property of resistance to vary the amount of X-rays we produce. The amount of resistance in a conductor is determined by four things. They are:

- The kind of conductor
- The length of the conductor
- The cross-sectional area of a conductor
- The temperature of the conductor

## TYPES OF CIRCUITS

You will learn the resistance circuit, the series circuit, and the parallel circuit.

The resistance circuit is the simplest type of circuit. You will find that knowing it will help you to understand more fully the other two. It must have a source of voltage, a current flowing in one direction, and a resistance. If you take a dry cell battery and connect a wire to the terminals you will have a simple circuit. Now place a switch and a resistance along the wire and you will have a resistance circuit. CURRENT WILL ONLY FLOW WHEN IT HAS A COMPLETE PATH TO TRAVEL. If the switch is not closed, current will not flow. When the switch is open, or there is a break in the conductor, then the circuit is said to be an OPEN CIRCUIT. When the switch is closed it is said to be a CLOSED CIRCUIT.

The series circuit is quite similar to the resistance circuit. In this type of circuit your devices are connected in ONE ROW. This circuit is one which uses current. The voltage in this type of circuit drops as it forces current through each device. If one of the devices in a series circuit "burns" out, the current will not travel about the circuit; you will have an open circuit (Figure 2-11).

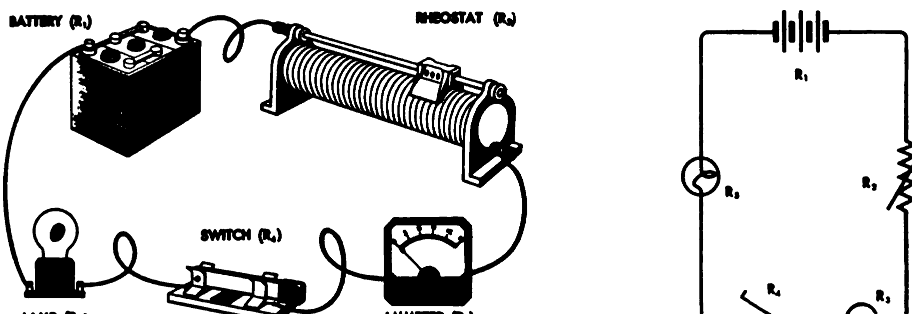



Figure 2-11 Series Circuit

The parallel circuit is also a circuit that uses current. In this circuit the devices are connected as branches to the main circuit. In this type of circuit the voltage is the same through every device. If one of the devices "burns" out the current will still go through all the others.

The parallel circuit is the type that is most frequently used. It is the one you are using now to light your office or barracks. When additional devices are added to a series circuit, each device will use that much more voltage until none of the devices

will work the way they should. A string of lights would be all dim when they should be bright.

In the parallel circuit the resistance of the circuit is decreased. This means that if the resistance is decreased the amperage is increased. When more devices are connected to this type of circuit than should be, the loss of resistance will cause you to have too much amperage and will cause the circuit to become OVERLOADED. This overloading is why you use fuses. If the overload passes a certain point, the fuse will "blow" and open the circuit (Figure 2-12).

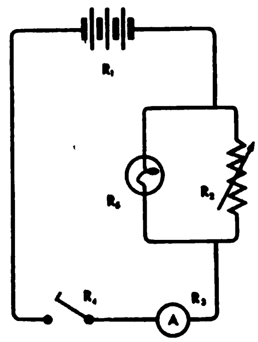



Figure 2-12 Parallel Circuit

You should know now that current is a flow of electrons, the meaning of potential difference, that electricity flows from negative to positive, the meaning of voltage, amperage and resistance and the types of electrical circuits. Your next step is to learn about ..................

## MAGNETISM

Magnetism is the ability for metals to attract certain other metals. The idea of magnetism is much larger than this, but for your purpose this will give you what you'll need. In X-ray we use magnetism in many of the devices of the machine.

TYPES OF MAGNETS. There are three types of magnets. They are neutral magnets like the earth, man-made magnets of hard steel or iron, and electromagnets produced by an electric current.

PROPERTIES OF MAGNETS. You must learn three things about a magnet. They are:

- Every magnet has TWO POLES, one on each end. One is called the North Pole and the other the South Pole.
- Like poles of a magnet repel each other. Unlike poles attract each other. (This is the same as electrical charges, remember?)

- The force of attraction between two poles depends upon the strength of the poles and how close they are to each other. For example, if the strength of a pole is doubled the force of attraction would be doubled. If the poles were one inch away from each other they would have a certain amount of attraction, but if they were moved apart two inches or the distance between them were doubled they would have only one-half the original attraction.

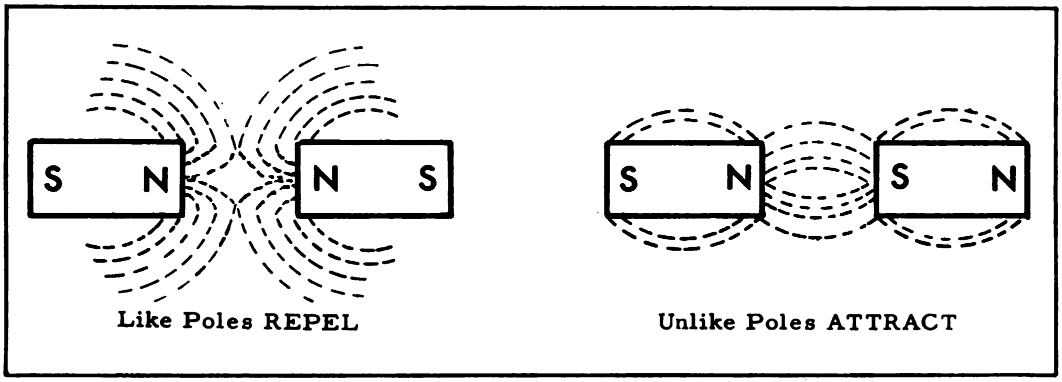



Figure 2-13 Properties of Magnets

MAGNETIC INDUCTION. Magnetic induction is the property of magnets to make magnets out of pieces of metal that are brought near them. If you have an iron magnet and you bring another piece of iron near the magnet's pole you will "induce" poles in the other piece of iron.

MAGNETIC FIELDS. Magnets are surrounded by "magnetic fields". This is what causes the magnetization of other pieces of metal that are brought near it. These "fields" are made up of "lines of force". The strength of the magnetic field is dependent upon the NUMBER OF LINES OF FORCE SURROUNDING IT (Figure 2-14).

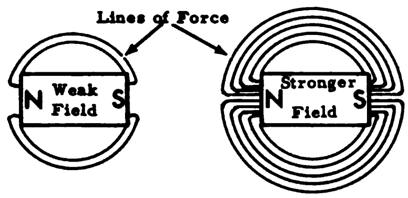



Figure 2-14 Magnetic Fields

LINES OF FORCE. These lines of force have some pecularities you should know about (Figure 2-15).

- They travel in curved lines about the magnet.
- It is thought that they leave from the north pole of the magnet and enter the south pole.
- These lines repel each other when they travel in the same direction.

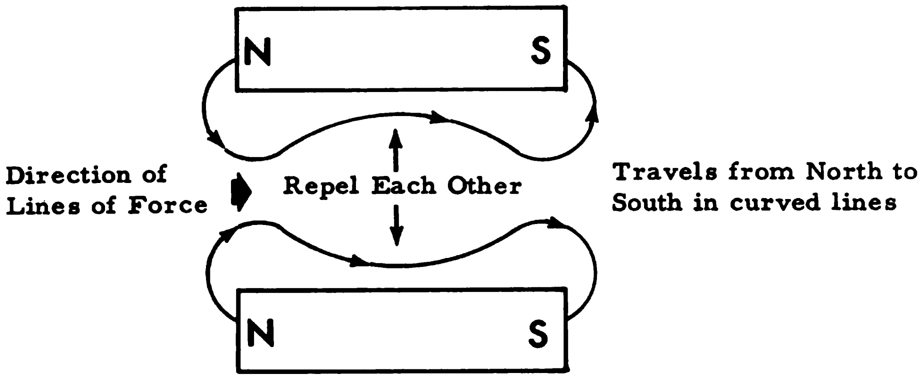



Figure 2-15 Lines of Force

You should now have the basic facts in mind about magnetism. It is time for you to go on to ..................

## ELECTROMAGNETISM

Whenever an electric current is present there are magnetic fields set up around the conductor. When the current is not on there is no magnetic field (Figure 2-16).

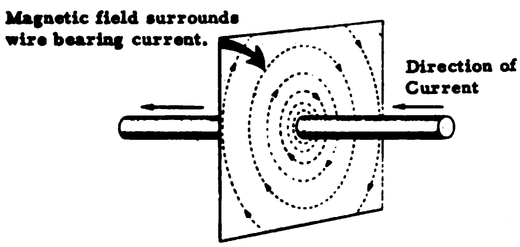



Figure 2-16 Magnetic Field Produced By Current

ELECTROMAGNETS. Electromagnets are made of coils of wire like a bed-spring. They have a south pole on one end and a north pole on the other. A soft iron core is inserted into this coil. This concentrates the lines of magnetic force. The coil, with the iron core, is also known as a SOLENOID. The electromagnet is used in X-ray machines for remote control switches and in relays which you will learn about later (Figure 2-17).

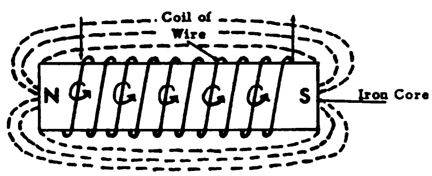



Figure 2-17 Electromagnet

**ELECTROMAGNETIC INDUCTION.** Just as the magnet could "induce" a magnetic field in a piece of iron, electric current causes magnetic fields around a wire.

Whenever you move a wire through a magnetic field or move a magnetic field around a wire you will "induce" in that wire an electric current. This is important for you to remember. This is known as ELECTROMAGNETIC INDUCTION. The amount of this induction is dependent on four things. They are:

- The speed which this conductor or wire cuts the lines of force in the magnetic field. The faster the lines are cut the more voltage induced.
- The strength of the magnetic field. The more lines of force the more induced voltage as they are cut.
- The angle formed between the wire and the lines of force. At an angle of 90 degrees more lines of force are being cut and this will produce more induced voltage.
- The number of turns in the wire. The more turns the higher the voltage induced.

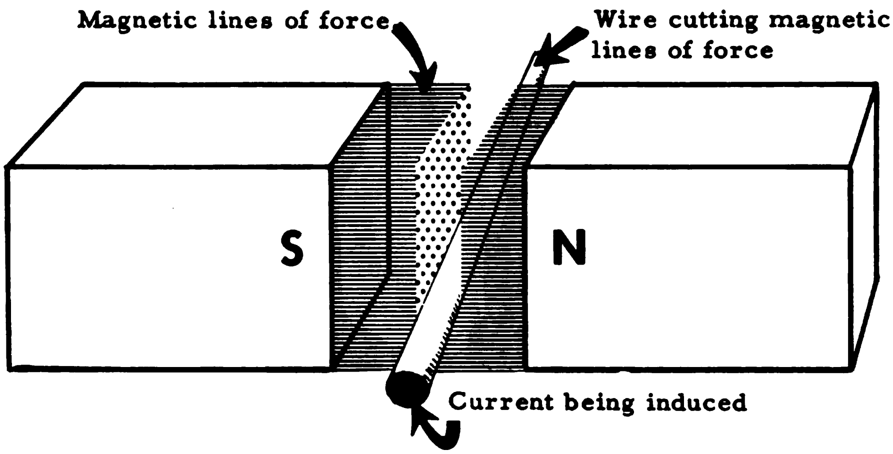



Figure 2-18 Electromagnetic Induction

This current will only be produced when this wire is cutting lines of force in the magnetic field. Besides the electromagnetic type of induction there is ......

**SELF INDUCTION.** The instant that you close a switch and send electrical curtent through a wire, that wire produces a magnetic field. This magnetic field expands outward like a balloon being blown up until it reaches its peak expansion. While it is doing this the lines of force making up that field are cutting the wire and "inducing" an "opposing" voltage in the wire. When the switch is opened and the electrical current is stopped this magnetic field contracts, as when you release the air from the balloon it deflates. As these lines of force contract they cut the wire also. This "induces" an electrical current into the wire and maintains this current momentaily even after the switch has been shut off. This principle is used in a device in the X-ray machine that you will learn as you study the parts of the machine (Figure 2-19).

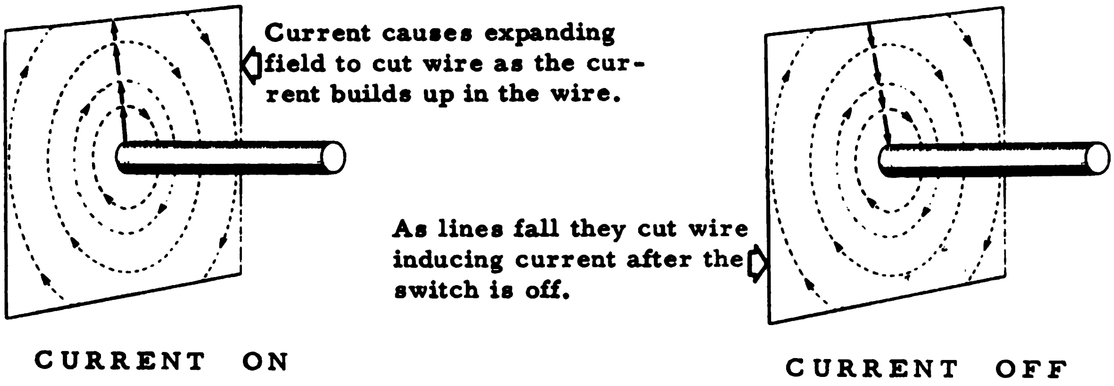



**Figure 2-19 Self Induction**

There is another type of induction you must know about and that is .........

**MUTUAL INDUCTION.** Mutual induction is a very important principle in the production of the very high voltage required to produce X-rays. When a current in a wire is increased, decreased, or the direction of this current is changed, the lines of force are expanding and contracting. Now when you put a second wire near the first wire, the lines of force in the magnetic field will cut this wire and "induce" an electric current in it. This kind of induction is known as MUTUAL INDUCTION.

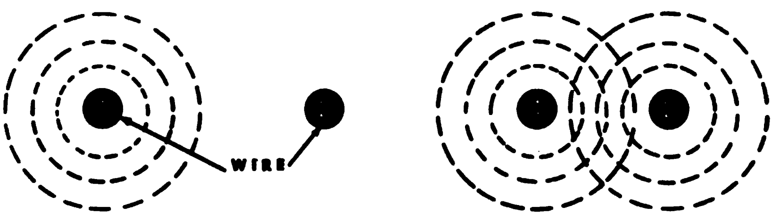



**Figure 2-20 Mutual Induction**

## A.C. AND D.C. GENERATORS AND CURRENT

Electric generators work on the principles of induction. The operation of an electric generator is dependent on a magnetic field and a wire cutting that field. On the basis of the principle of induction two types of current can be produced with electric generators. These two types of current are the alternating current and the direct current.

### ALTERNATING CURRENT

Alternating current is a current which flows in a wire first in one direction and then in the other direction. This reversal of the current, as you should know, causes the magnetic field around the wire to change. How is the current produced?

To produce an alternating current, an alternating current generator is used. This is a device that has a wire conductor rotating between two or more magnets. The wire conductor is now called an ARMATURE. This armature is rotated mechanically between the magnets. The ends of the armature are inserted and connected to two round SLIP RINGS. Each end is connected to its own slip ring. The slip rings have a METAL BRUSH touching them. It allows the rings to turn but it maintains contact with them. These metal brushes are connected to the wires of the circuit. Study figure 2-21 and the following explanation carefully.

If the armature of the generator is moving clockwise, with 1 coming up, you will have a current induced that will travel from 1 through 2 and enter the circuit through slip ring 4 and then return through slip ring 3.

When 1 moves over to where 2 WAS, the current will flow from 2 through 1. You will notice ring 1 is going DOWN. The current will pass out to the circuit through slip ring 3 and return through slip ring 4. You see now that when 1 is coming up the current is going in one direction. When it is coming down the current is reversing its direction in the circuit. Now you know that this reversing of the current causes the current to rise and fall in strength. It builds up to a peak and then falls to nothing. This happens twice - first when it builds up with the current going in one direction and again when the current is going in the other direction. When the current does this it is positive in one direction and negative in the other direction.

One complete revolution of the armature is known as a CYCLE. Within each cycle there are two IMPULSES. When the current is going in one direction and is positive, it is a POSITIVE IMPULSE. When it is going the other way and is negative, it is a NEGATIVE IMPULSE. These impulses are also known, probably more commonly, as alternations.

In X-ray you will be using equipment that uses 60-cycle current. The 60 cycles means that there have been 60 complete revolutions of the armature. Electrical current has a frequency just as your X-ray wavelength does. The MORE CYCLES PER SECOND THE HIGHER THE FREQUENCY of the current. When you hear the term "60 cycles", this will mean 60 cycles PER SECOND. This will be the frequency of your current as well. When you have 60 cycle current you will have 120 impulses or 120 alternations per second. Remember this fact about 60 cycle current as it is important that you know this when you learn about X-ray timers and other devices later.

## DIRECT CURRENT

Direct current is current which does not change direction. The electricity from a battery is an example. This type of current is necessary in the X-ray tube. Alternating current is used in the other parts of the machine.

Direct current is produced in the same manner as alternating current, with magnets and an armature. But a D.C. generator does not have slip rings. It has one ring that is split into two halves. This is called a COMMUTATOR. Each end of the armature wire is connected to one of these halves of the ring.

When 1 moves up, current is produced and passes through 2. It then travels to the circuit through 3 and returns through 4. Now when 1 is moving down the current still passes through 3 and returns through 4. STUDY THIS CAREFULLY UNTIL YOU CAN SEE HOW THE CURRENT FLOWS.

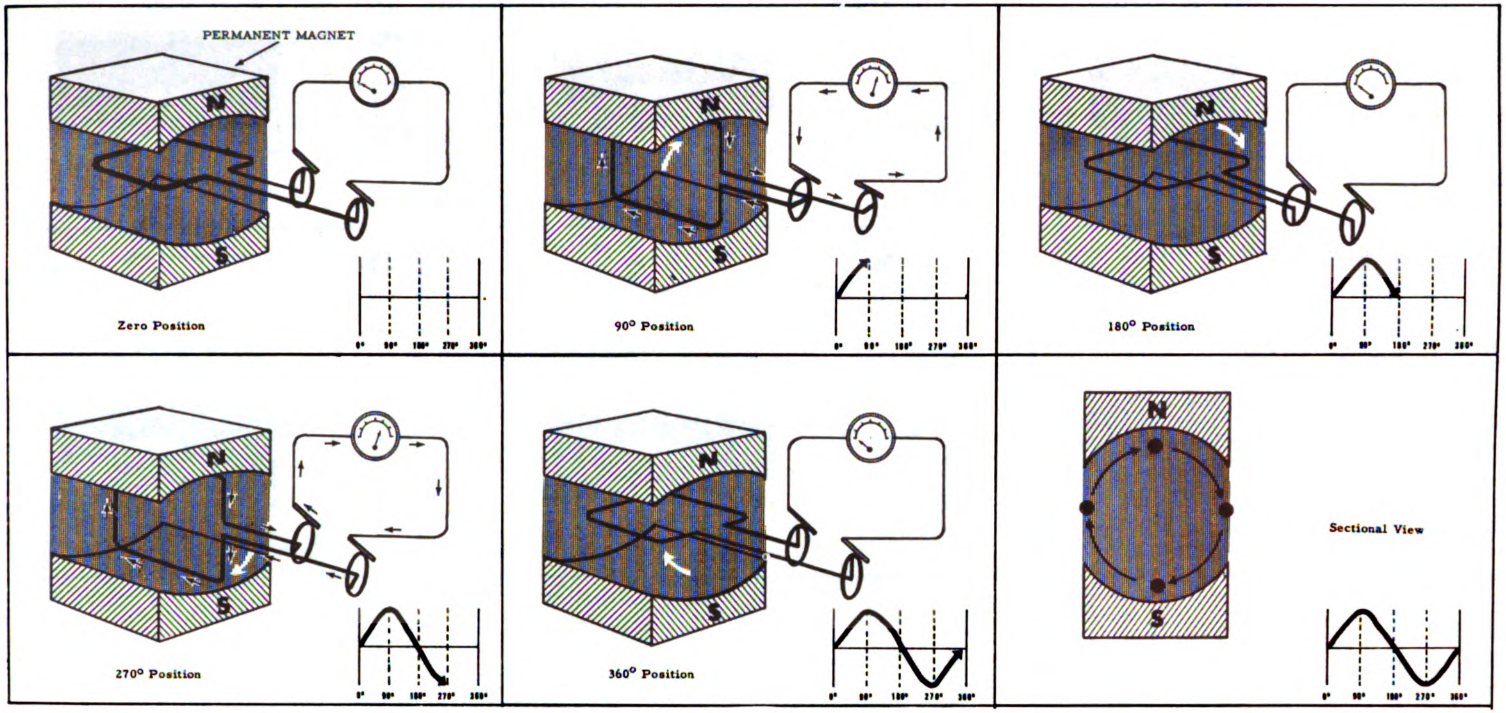



Figure 2-21 A.C. Generator

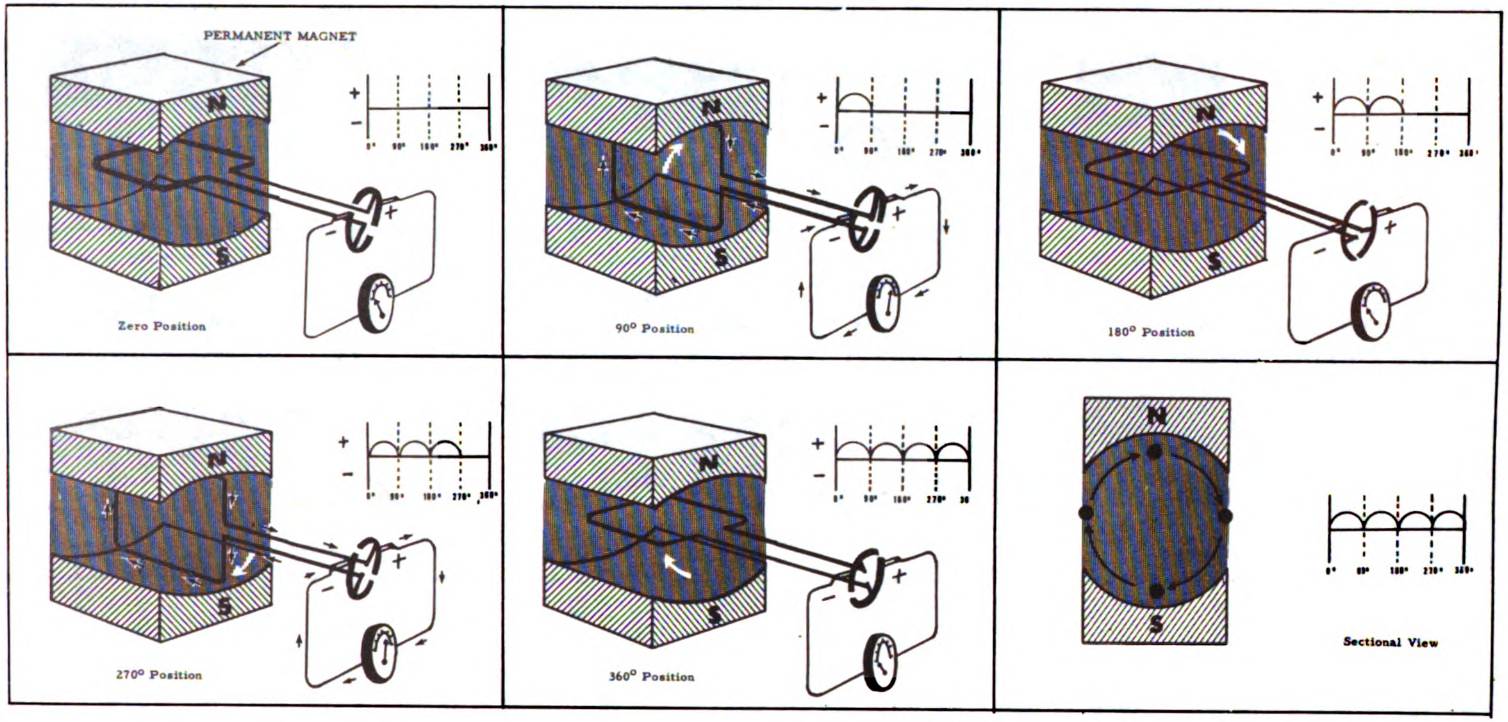



**Figure 2-22 D.C. Generator**

The current produced in the D. C. generator is PULSATING DIRECT CURRENT. Because the current does not change direction it will rise to a peak and fall, but will not change SIGNS like alternating current. As the wire conductor starts from 0 and begins to cut the lines of force in the magnetic field, the current will build up to a certain point and then begin to fall as less lines are cut. It is like pumping water from a well.

## BEHIND AND AHEAD

You have covered a number of things to this point that will help you understand what is ahead of you. You have learned about electrical current, types of electrical circuits, voltage, amperage and resistance. You know some of the properties of magnets, about magnetic induction, magnetic fields, lines of force and electromagnets. You should understand what electro-magnetic induction, self-induction and mutual induction are. You also have an idea of what alternating and direct current is, and how it is produced.

Ahead of you lies the X-ray machine. You will find out about the major devices of the X-ray machine and how these work. You will get to know and understand your machine.

## THE X-RAY MACHINE

Your X-ray machine will generally be divided into three major units. These are the control unit, the transformer unit and the tube unit. Most X-ray units also have an X-ray table. You will learn about your X-ray machine in this chapter.

### CONTROL UNIT

The purpose of any control unit is to show you how your unit is operating and to allow you to set up the machine for various types of exposures.

Most controls on X-ray machines will have the following devices:

- Line Switch
- Line Compensator Switch
- Kilovoltage Selectors
- Milliampere Selectors (Radiographic and Fluoroscopic)
- Kilovoltage Meter
- Milliampere Meter

- Fluoroscopic and Radiographic Timers
- Hand and Foot Timer Switches
- Line Compensator Meter (Voltage Compensator)
- Bucky Switch
- Stereoscopic Device Switch
- Auxillary Device Switches
- Circuit Breaker

Look at your machine and see if you can find these things. Now, let's take these various devices and see how they operate and what they look like.

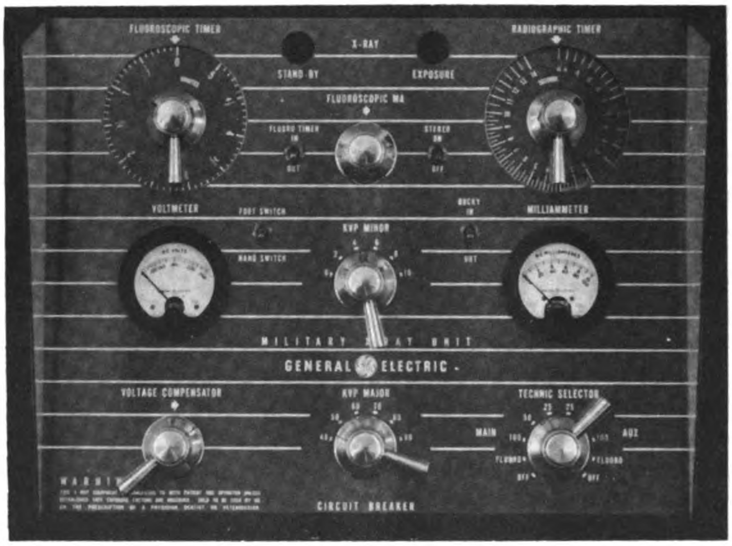
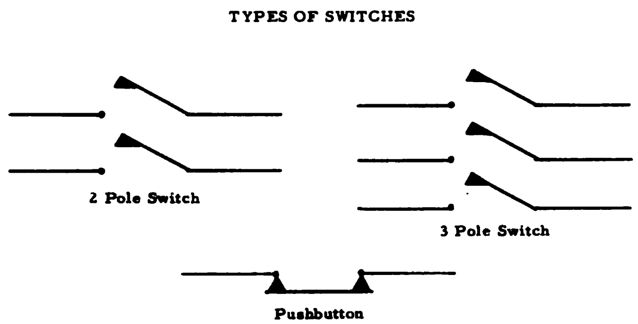



Figure 2-23 Control Unit Panel

SWITCHES. A switch is a device that will open or close a circuit. There are many types of switches but they all serve one general purpose. With the switch closed, current has a complete path and will flow. With the switch open the circuit is open or "broken" so current cannot move through the circuit. Notice the types of switches in the room you are in now; the light switch on the wall; the spring switches on your machine that you have to hold up to keep the circuit closed; the large switch box for the machine. Examine these switches to get an idea how the various types work. The push button on your X-ray machine or timer is a switch (Figure 2-24).

FUSES. A fuse is a device used to guard against overloading circuits with too much amperage. This device has a thin metal strip or wire which is connected into the circuit. When too much amperage is in the circuit the strip or wire will melt and break or open the circuit. In X-ray you will be using fuses which will burn out if your machine becomes overloaded. You will be using fuses with a capacity of 3,

6, 10, 15, 30 and 60 amps. Ask your NCOIC to show you what size fuses you use in your machine. (Figure 2-25).



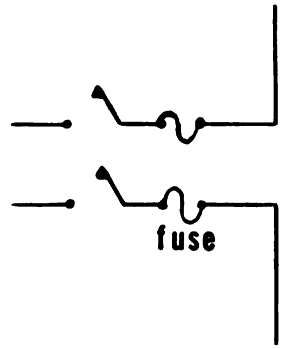




Figure 2-24 Types of Switches

Figure 2-25 Fuses in Circuit

LINE COMPENSATOR. Voltage coming into your building sometimes varies. It may be 110 or 220, but not always exactly 110 or 220. This variation in voltage will have an effect on your machine. This variation in line voltage coming into your machine is corrected by the line compensator. This device is either connected to the main line by straps or you have a tap that you can turn to different settings. Find this device on your machine. A voltmeter is placed so you can tell if the machine is compensated correctly. It will have a red line on which you set the needle of the meter. When the needle is set the machine has the correct voltage. This device makes the machine produce the proper voltage even if the line voltage varies. (Figure 2-26).

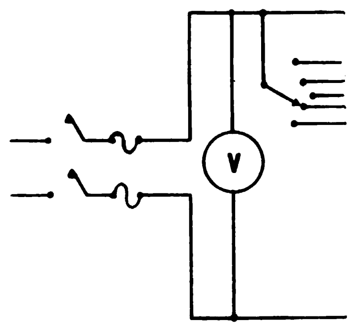



Figure 2-26 Incoming Line Compensator

KILOVOLT SELECTORS. In your machine you have a very important device known as the AUTOTRANSFORMER. This device is used to provide a means of controlling the voltage that you will use in the high tension transformer which you will learn about very shortly. The autotransformer is connected between the incoming line and the primary coil of that transformer (Figure 2-27).

The autotransformer is a coil of insulated wire that is wrapped around a soft iron core. At regular intervals, wires are drawn off this coil to little metal buttons which are placed in the form of a half circle. A moveable contactor can be moved to touch any of these buttons. By moving the contactor you can control the voltage that is going to the other transformer.

The autotransformer works on the principle of SELF INDUCTION. Review this principle. When the wire is made into a coil and wrapped around an iron core the strength of the magnetic field is greater. This also causes more of the "bucking" or "opposing" induced voltage. Remember that you are using alternating current. If you start at the bottom of the autotransformer you will not have so much bucking, so the voltage will not be reduced much. But as you tap the wires higher up you will keep getting a lower and lower voltage. This is the way you control the kilovoltage.

On most machines you have two kilovoltage selectors. One is known as the MAJOR and the other the MINOR. The major will raise or lower your voltage by 10's and the minor will raise or lower the voltage by 1's or 2's. This helps you to make refinements in your settings. This means also that you will have two sets of wires coming off your autotransformer with a moving contactor for each set. Look at the kilovolt selectors on your machine. Turn the knob and feel the contactor as you set it up and down.

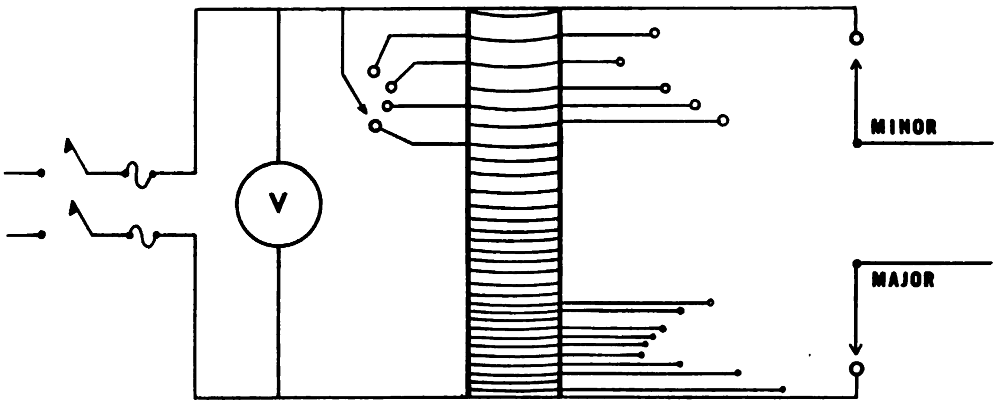



Figure 2-27 Autotransformer and KVP Selectors

MILLIAMPERE SELECTORS. Milliamperage is used to heat the "filament" of the X-ray tube so you can have a source of "free" electrons. If you want more electrons you use more milliamperes. You have machines with milliamperage capacities of 10, 15, 30, 100, 200, 300 and 500. The higher the milliamperage capacity of your machine the more flexibility you will have in setting techniques on it.

You will find a great need for varying your milliamperage in X-ray. You do not need to use as much X-ray on some parts of the body as you do others. Because of this you have devices that will enable you to select various milliamperages.

There are two types of devices that can be used to let you change your milliamperage. One is a RHEOSTAT and the other is a CHOKE COIL (Figure 2-28).

The rheostat is a VARIABLE RESISTOR. A resistor is a device which resists the flow of current through it. This device is a coil of wire that is insulated and wrapped around a porcelain core. A thin portion of the insulated wire is scraped off from one end of the coil to another. A metal slider makes contact with this strip of exposed wire and can slide up and down the coil. Then, again, just certain spots along the coil can be uncovered and taps connected so that each spot will have a certain resistance.

This device works on the principle of self-induction, too. When the metal slide is near the bottom of the coil (or you use a low tap), you will have less "opposing" voltage and can get more current through to the filament. The higher up you go the more resistance you will meet and the less voltage you will have to push the current through. By reducing the voltage you will have less current available to heat the filament. The less heat the fewer electrons. If you have a push button milliampere selector you probably have the tap type of rheostat.

The CHOKE COIL is a coil of wire which has a moveable core of soft iron that can be pushed in or out of the coil. This coil also uses the principle of self-induction. The farther the core is pushed into the coil the more opposing voltage will be produced. Remember that the core strengthens the magnetic fields surrounding the coils of the wire. Look at your machine and see if you can find the milliampere selector. If you have the push button type, find the fluoroscopic milliampere selector. Turn the knob and feel how it turns. If it clicks you have a tap type. If it slides around smoothly you have either the slide type of a choke coil.

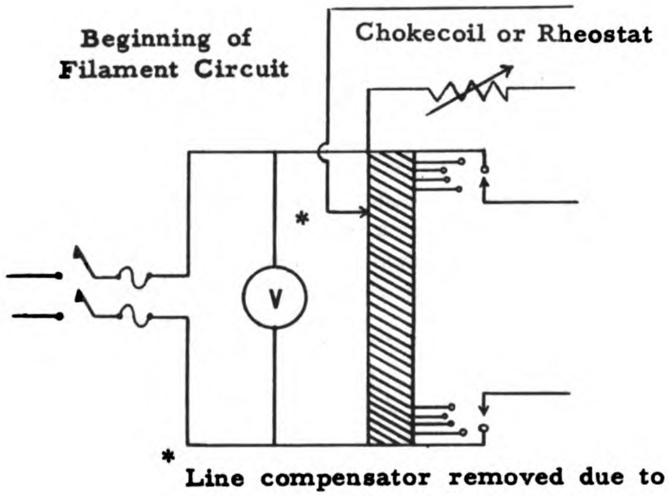



Figure 2-28 Milliampere Selector

TIMERS. You will be using one of five types of timers on your X-ray machine. Time on your machine is the amount of the time that you are impressing the high voltage across your X-ray tube. The five types of timers are:

- Hand Timer (Mechanical)
- Synchronous Timer
- Impulse Timer
- Phototimer
- Electronic Timer

Check your machine and see what type of timers you have on it. Usually it will be a synchronous timer or a hand timer. You may also have an impulse timer on

machines with 100 milliamperes or over.

The synchronous timer uses a synchronous motor. It can be set for 1/20 to 15 seconds or more. It is called a synchronous timer because the motor which runs it must rotate at the same speed as the alternating current or generator which supplies it with power. It is limited because of this fact and cannot be faster than the generator running it.

The impulse timer, however, gets down to 1/120 of a second. It is used more commonly at 1/60th of a second. Do you recall that the alternating current used in X-ray is 60-cycle? And each cycle had two impulses or alternations? It is these impulses that you are using. If you used 1/120 of a second you would only be impressing the voltage across the tube for the time it takes to produce one impulse of current. This is an advantage in X-ray. You will see how much of an advantage it is later.

The hand timer is a mechanical timer. It is connected to the machine so that when the button is pushed it closes the circuit and allows the voltage to flow. When the time is up the circuit is broken. This type of timer is used on portable equipment and field equipment. If you have one in the department take a look at it. Set it for some time and you will see that you do not need electricity to work it. It is only good for larger amounts of time; from 1/4 second to 15 seconds or more.

The phototimer is a device that turns off the machine automatically and does not have to be set each time. The length of time used depends on the part and thickness of the body being X-rayed. This timer uses the ability of X-ray to cause fluorescence in crystals. The light from the crystal passes through a phototube and when enough X-ray is given the phototube activates a device which shuts the exposure off. It is something like the electronic eye you have seen in some stores.

The electronic timer is a new type of device that enables you to use from 1/30 of a second to 20 seconds.

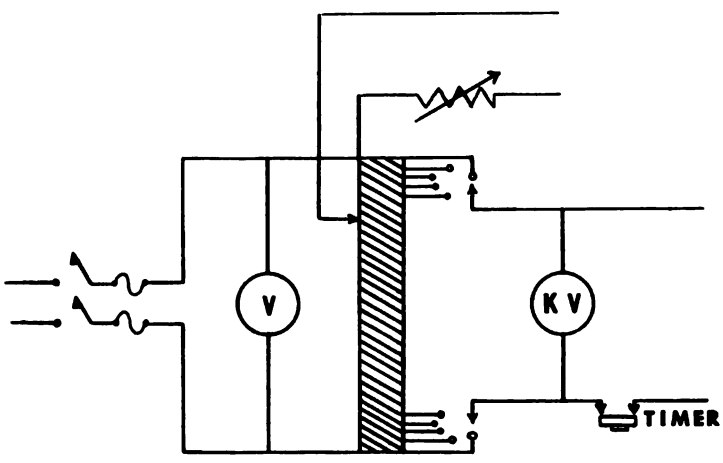



Figure 2-29 Timer

METERS. If you will look at your machine you will see that it has several meters. These meters will tell you just how much voltage, kilovoltage or milliamperage you are getting. They are current measuring devices. They work on the principle of the "d'Arsonval galvanometer".

If you have a coil of wire placed between two magnets and a direct current is passed through this wire, the wire experiences a side thrust caused by the action of the magnetic fields of the wire and the magnets. Review the discussion on the lines of force. Remember that the magnetic lines of force repel each other if they are traveling in the same direction! The degree of this thrust will, of course, be determined by the strength of the magnetic fields. The more current in the wire the more side thrust you will get (Figure 2-30).

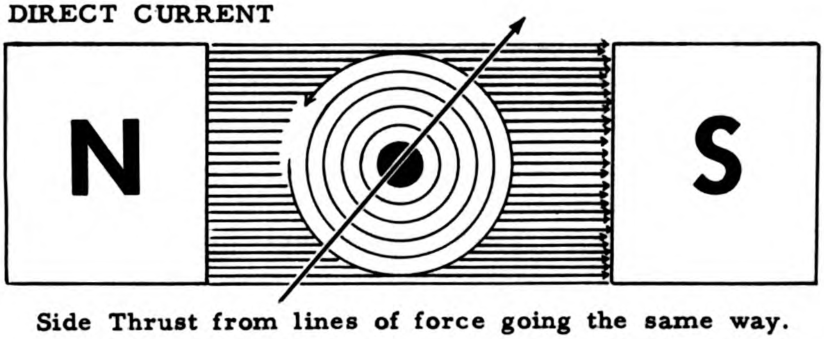



Figure 2-30 Principle of Meter

Now if this coil is set between the poles of a magnet with one end fixed and the other connected to a coiled spring you will have a simple type of meter. With direct current causing a magnetic field in the wire and the lines of force repelling each other, they will cause the coil to rotate. Because the coil is attached to a spring, the coil will be returned to its original position when current is no longer flowing through it. If a needle pointer is attached to the coil and a scale constructed to mark the amount of rotation as the amount of the current in the circuit, you will have a voltmeter or ammeter. The farther the needle is rotated on the scale the greater the current in the circuit (Figure 2-31).

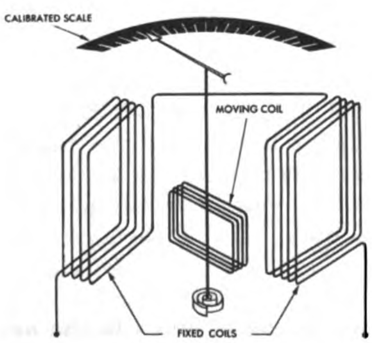



Figure 2-31 Simple Meter

Now all this involves direct current. You are using alternating current. If you used a plain magnet your needle would be waving back and forth 120 times a second. This will not do. You must use the poles of an electromagnet that is using alternating current. Because the current in both the coil and the electromagnet are both moving back and forth, the needle will not move. The current is reversing in both of them at the same time keeping the needle steady.

Look at the meters on the machine. Turn the machine on and watch the kilovolt meter needle. It moves up or down as you turn the selector knob. Up with the needle means that there is more voltage so you have more magnetic lines of force in the electromagnet coils. This causes the movable coil to rotate farther so the needle will read higher.

More than likely the meter you are looking at is a meter known as a PRE-READING KILOVOLT meter. This meter is connected in parallel with the autotransformer. It is really showing volts going to the high tension transformer. However, these volts will be turned into so many thousands of volts once it gets to the big transformer and what you see is the amount of KILOVOLTS you will produce in the big transformer.

The milliammeter is used to show the milliamperage flowing through high voltage circuit and the tube. The milliammeter is connected in series in the center of the secondary side of the high tension transformer and is GROUNDED.

You now have gone through the control unit to some extent. Some of the things you have been learning will be more clearly shown to you as you take up the ......

TRANSFORMER UNIT. The whole principle of X-ray is based on the ability to produce very high voltages that will drive the electrons across the tube to the target. This is made possible by using the principles of "mutual induction". Remember that an electrical current can be induced into a wire that is near another wire carrying current. The first wire spreads out its magnetic field and when this field cuts the second wire a current is produced in that wire also. The transformer, then, is a device that can change low voltage to high voltage or high voltage to low voltage.

The simplest form of a transformer is two separate coils of wire. These coils are insulated and are parallel to each other. The first coil is said to be the PRIMARY side and is supplied with alternating current. The second coil is known as the SECONDARY side and receives its alternating current by "mutual induction" from the primary coil.

The amount of voltage that can be induced into the secondary of the transformer is dependent UPON THE NUMBER OF TURNS OF WIRE IN THE SECONDARY COIL. The more turns of wire in the secondary the higher the voltage produced. If the primary coil has only 1 turn and the secondary coil has 10 turns, you can produce in the secondary coil a voltage of 10 volts if 1 volt is in the primary. If the primary coil has 10 turns and the secondary coil only 1 turn, then you can only produce 1 volt in the secondary coil.

The transformer that has more turns of wire in the secondary coil than in the primary coil is known as a STEP-UP TRANSFORMER. A transformer which has more turns in the primary than in the secondary coil is a STEP-DOWN TRANSFORMER.

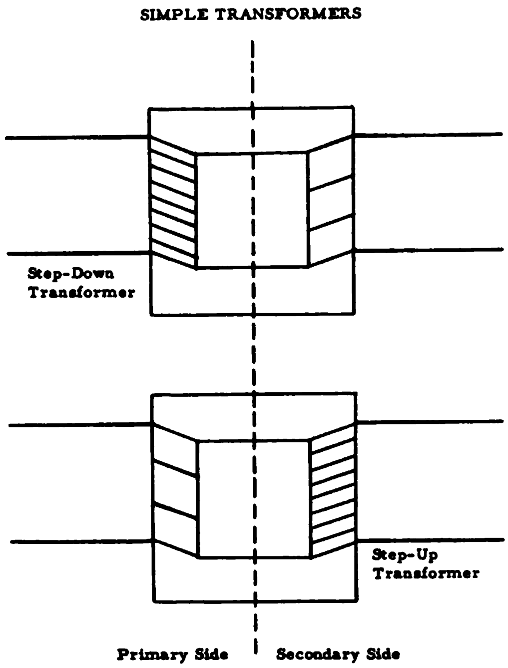
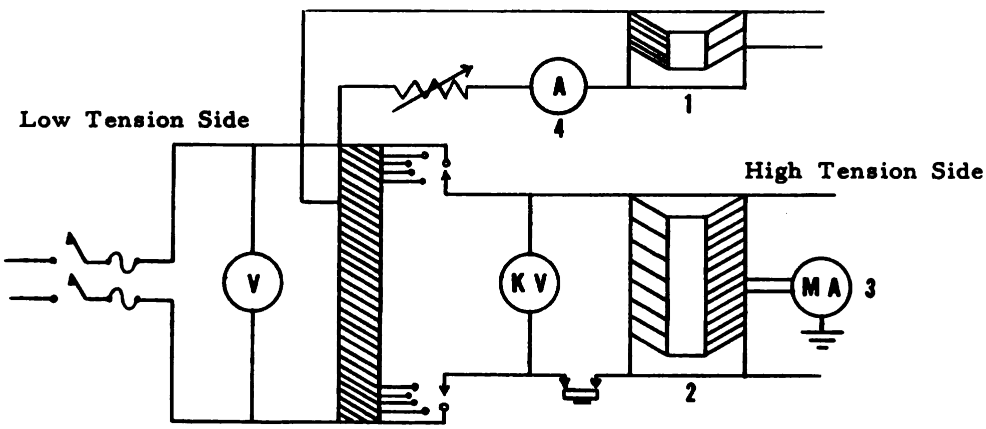



Figure 2-32 Simple Transformer

In X-ray you know that you use 110 to 220 volts. With a step-up transformer you can produce 30,000 to 100,000 volts (30 to 100 kilovolts). You use this high voltage to drive electrons across the tube. Now in your tube you will also have to reduce this 110 or 220 volts to heat your filament. You use a step-down transformer for this because you only need from 8 to 12 volts to supply the filament (Figure 2-33).

All through the control unit and transformers you have been using alternating current. An X-ray tube has to have direct current flowing through it. This brings you now to the very important process of rectification.




1. step-down transformer 2. step-up transformer
3. milliammeter 4. filament ammeter

Figure 2-33 Low and High Tension Circuits

## RECTIFICATION

Rectification is the process of changing alternating current to direct current. Rectifiers change the alternating current to pulsating direct current. Rectifiers are located between the secondary of the step-up current transformer and the X-ray tube.

There are two types of rectification that you will use. They are self-rectification and valve-tube rectification. You will find self-rectification on portable units and the valve-tube type on the larger machines.

SELF-RECTIFICATION. Self-rectification is the simplest type of rectification. In this type only the X-ray tube is used. The electrons only travel to the target when that target is positive. Remember that electrons have a negative charge. Now the alternating current has two impulses. One of them is positive and the other negative. When the current changes and makes the target negative you will not have a flow of electrons. In other words you are "suppressing" the flow of electrons in that impulse. This shows that the X-ray tube itself is rectifying the current.

Now this suppressed negative impulse in the alternating cycle is a disadvantage. It is known as "Inverse Voltage". If your tube is overloaded until the target gets too hot it will release electrons and damage the filament of the tube or break the vacuum bulb which contains it. Because of this you cannot use as large an exposure with this type of rectification as you can with the valve-tube type. Self-rectification is known as half-wave rectification because it only uses one impulse or wave of the alternating cycle (Figure 2-34).

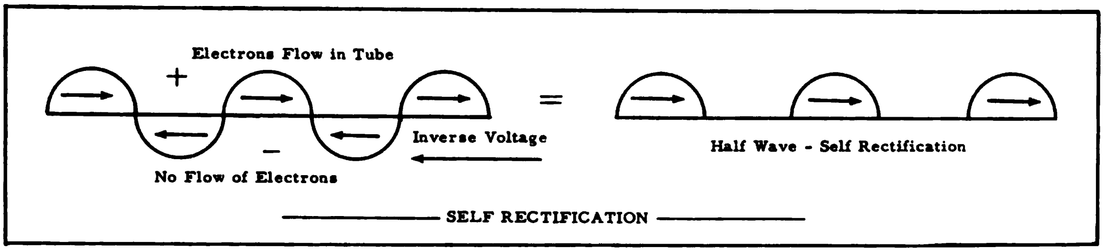



Figure 2-34 Self-Rectification

VALVE-TUBE RECTIFICATION. Valve-tube rectification causes current to travel only from the negative to the positive. The tubes that are used are similar to the X-ray tube in that they have a filament and a target. Valve tubes can produce both half-wave rectification and full wave rectification. Full wave uses the whole cycle. You can use one, two or four tubes with this system. When one tube is used it is for the purpose of keeping the target of the X-ray tube from getting hot and sending out electrons which would damage the tube. The rectifying tube would receive all the damage and you save your X-ray tube. The capacity of your X-ray tube is not increased, however. One tube will still give you half wave rectification (Figure 2-35).

When two tubes are used in the rectification process, you will receive half-wave rectification. That is, you will only get one of the impulses from your cycle. This will improve the capacity of your machine because the current will be rectified, BEFORE it gets to the tube (Figure 2-36).

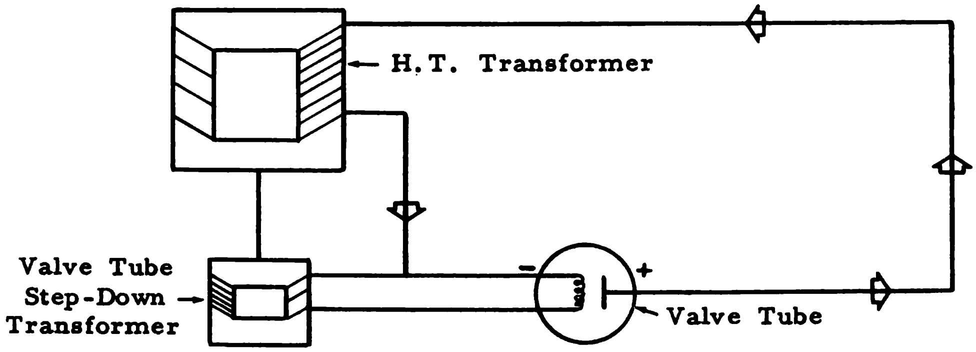



Figure 2-35 Valve Tube

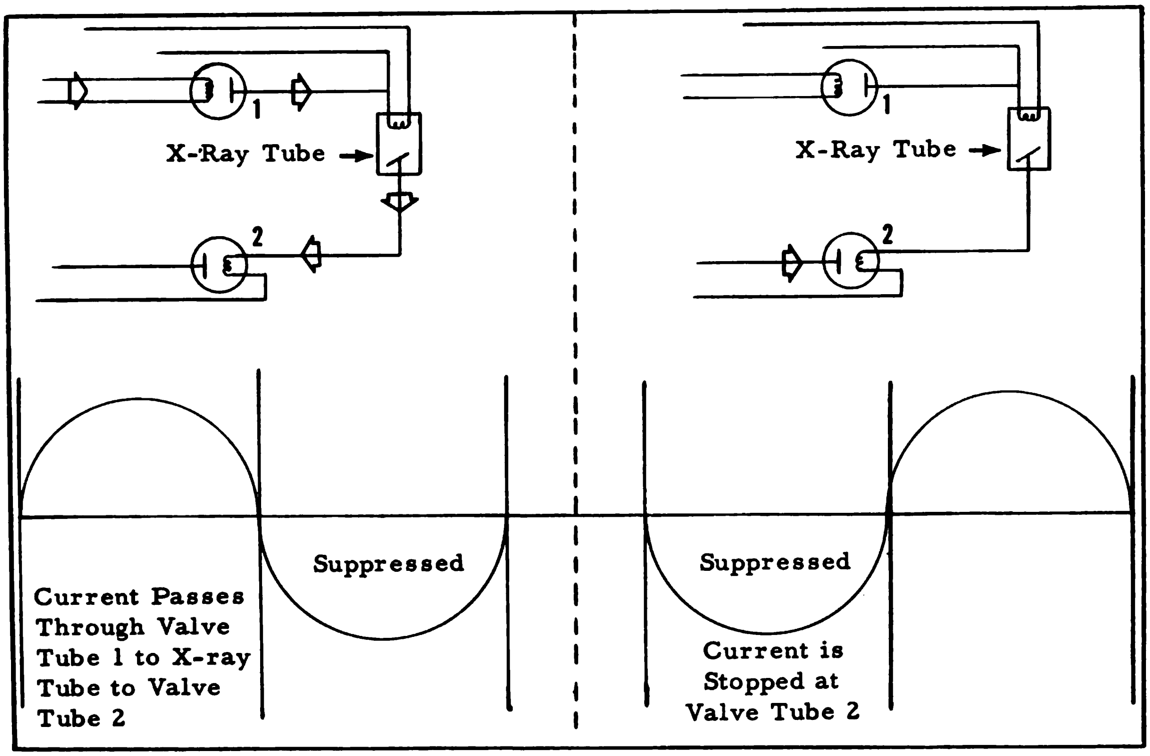



Figure 2-36 Two Valve Tubes

Most of the large machines use four tubes and give you FULL WAVE RECTIFICATION. You can use the whole cycle and this increases the capacity of your machine a great deal. See Figure 2-37, following page.

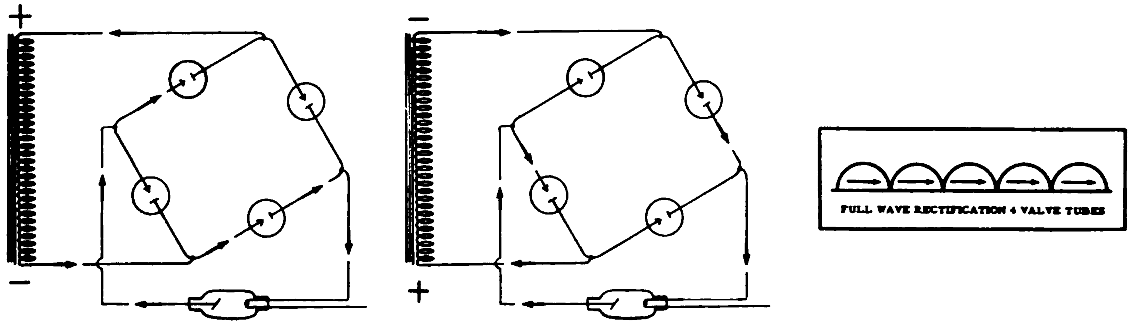



Figure 2-37 Four Valve Tubes

## X-RAY TUBES

All types of tubes used in X-ray are of a type called "hot cathode tubes". These tubes require the use of a heated filament to operate. Before going into the details of the X-ray tube look at the basic principles of all the hot cathode tubes.

- A filament must be heated for a source of electrons. The higher the temperature the more electrons freed.
- When kilovoltage is applied, electrons are driven from the filament to the target. The speed of the electrons depends on the amount of kilovoltage.
- When NO kilovoltage is supplied electrons will form a cloud around the filament of the tube.
- If the kilovoltage supplies the electron with enough speed, X-rays will be produced when the electrons hit the target.

Modern X-ray tubes have an anode and a cathode. These are housed in a lead glass vacuum envelope. This tube is in a housing filled with insulating oil.

### THE CATHODE

The cathode of an X-ray tube is the negative side of the tube. It consists of the filament, focusing cup and two separate circuits. The filament is made out of a tiny coil of tungsten metal wire. This metal is used because it can stand a great deal of heat without melting. The metal is of the same type used for light bulbs. This filament is connected to a low voltage circuit which heats it and is also connected to one end of the step-up transformer to provide the kilovoltage to set the electrons in motion. The focusing cup is a negatively charged molybdenum cup hollowed out so the filament can sit in it. This cup focuses the electron stream so that it will hit only a tiny area on the target. The filament uses 8 to 12 volts and from 3 to 5 amperes in operation. Many tubes that you will work with will have two filaments.

You will have a large and a small filament set side by side in the cathode. These filaments provide two different sizes of electron streams. The filaments service a large or small target. A larger load can be applied to the large target for exposure of heavier parts of the body. These tubes are called DOUBLE FOCUS TUBES. Only one filament is used at a time (Figure 2-38).

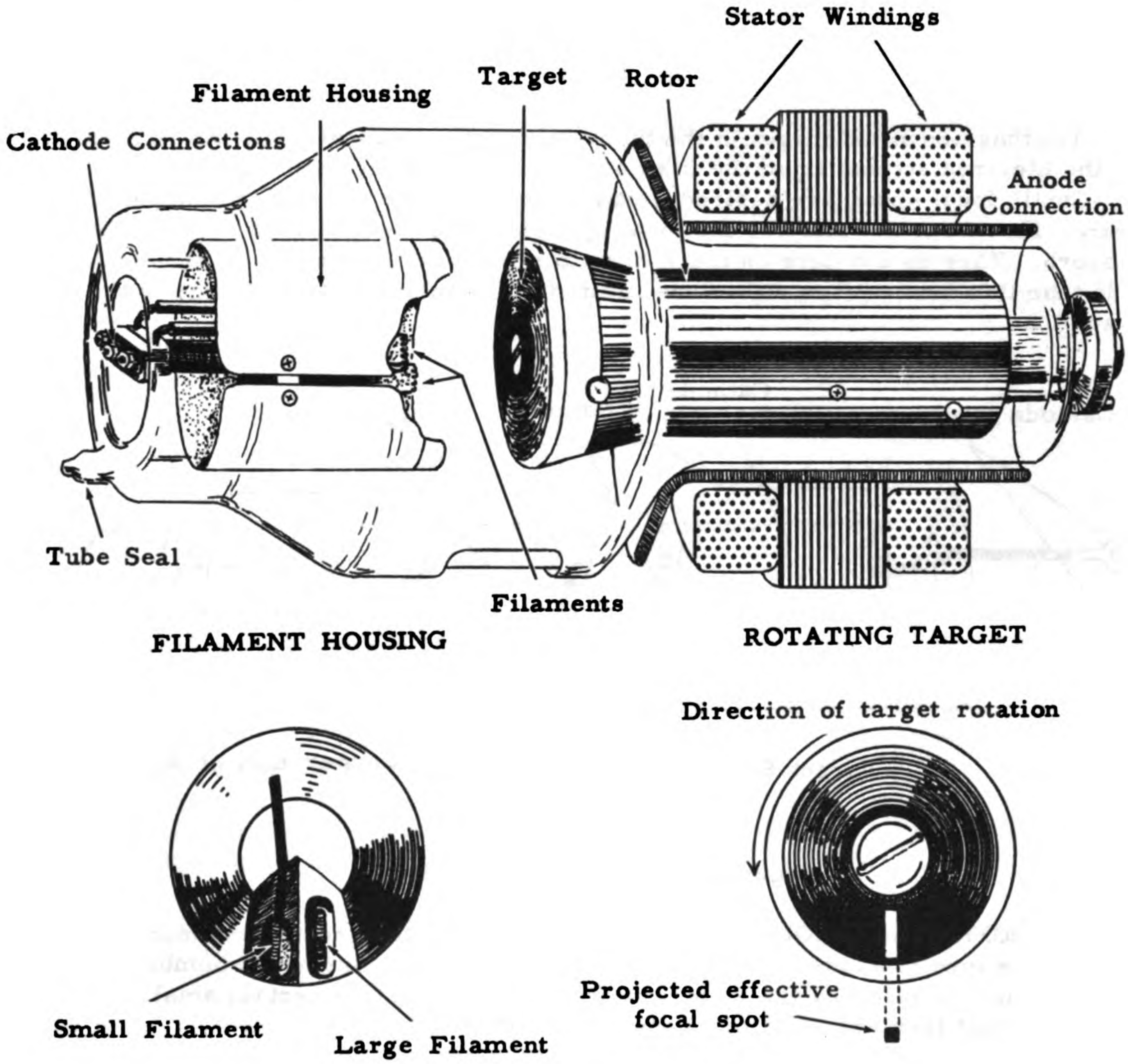



Figure 2-38 Rotating Anode Tube

## THE ANODE

The anode is the positive side of the X-ray tube. You will find that you will be using tubes that have STATIONARY ANODES AND ROTATING ANODES.

The STATIONARY ANODE has a tungsten metal target set into a block of copper. Tungsten is used in the target because it can withstand a great amount of heat. It is also an element that has a high atomic number which means that it has a good

number of electrons in its orbit. This type of element provides better production of X-rays with a high penetrating power (Figure 2-39).

Heat is the reason for the copper block. Although tungsten can stand a good bit of heat it can be damaged if you give it too much. When electrons hit a target only about .2% of their energy is converted into X-rays. The other 99.8% is converted into heat. Copper is a better conductor of heat so it can be used along with circulating water, oil or air to get rid of excess heat produced in the target. If the heat was not removed the target would melt or become "pitted". This destroys the usefulness of your tube.

The tungsten metal target in the tube is known as the focal spot. As you remember, the electron stream from the filament is focused by the focusing cup to this target. Small focal spots are desired because they provide you with a sharper X-ray picture. However, the smaller the focal spots become the less heat they will be able to absorb. They do not have as much area to spread the heat over. In the stationary anode tube this heat causes you to use limited techniques to avoid damage to the target and tube.

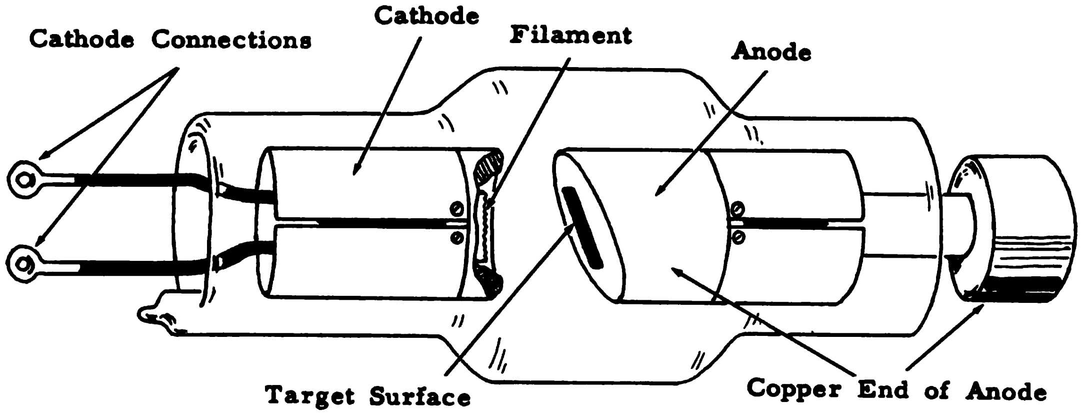



Figure 2-39 Stationary Anode

The ROTATING ANODE was developed to allow for greater exposures on the target. This type of anode has the tungsten target rotating during the bombardment by the electrons. In this way the electrons are still focused to a certain small area but the surface that they are striking is always new. Because of this the heat is not concentrated in one particular area but is spread over a much larger area (Figure 2-38).

## THE INDUCTION MOTOR

The target on a rotating anode tube is a round disc of tungsten and is attached to the shaft of an induction motor. This induction motor is an alternating current type of motor. It consists of a STATOR AND A ROTOR (Figure 2-40).

The stator is made up of an even number of electromagnets surrounding the rotor. The rotor is a soft iron core covered with bars of copper. The electromagnets are supplied with current which is known as MULTIPHASE current. This type

of current enters opposite pairs of coils out of step with the current in the successive pairs of coil. Now the copper bars on the rotor or shaft get a current induced into them from the electromagnets. This current is then lying in a magnetic field. Remember how a coil acted when you learned about meters. This rotor experiences the same side thrust because the lines of force in the copper bars and the field of the magnet are going in the same direction, so repel each other. This action opposite each electromagnet and copper bar rolls the rotor around and around. It is something like the old-time ship wheels that you see on clocks. The handles could be the magnets and the hands the copper bar. While one current steps from one handle, another one gets just ahead of it into the next handle. These currents then pull the hands around after them. When this is done fast enough you will have the rotor spinning around. This, then, is how the rotating anode works.

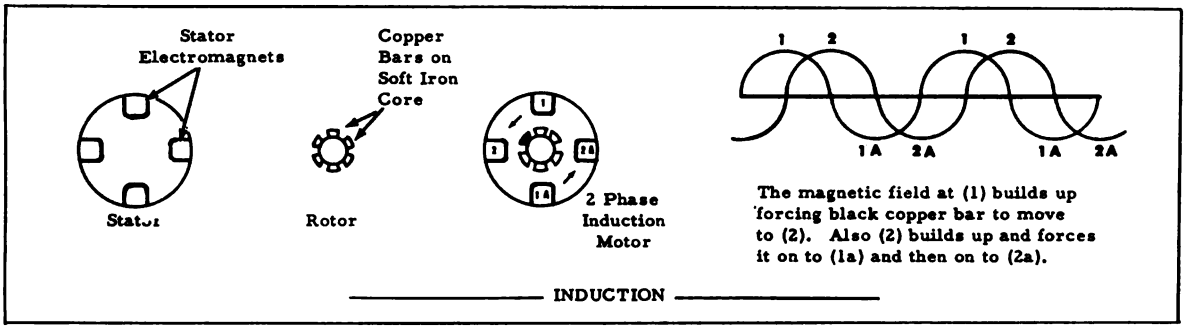



Figure 2-40 Induction Motor

If you have a rotating anode tube, remove the plates of aluminum in the tube head and make an exposure on your machine. The rotor will spin for a little while after the exposure so keep the machine on so that the filament will light up the anode. Watch how it spins. DO NOT WATCH IT DURING AN EXPOSURE. By doing this you will be able to picture the operation of the induction motor.

If you have a stationary anode tube look at it with the filament on and you can see the target spinning in the copper.

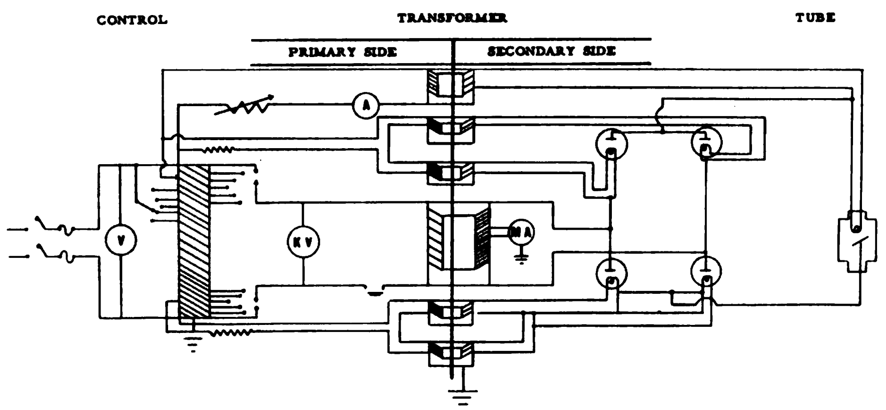



Figure 2-41 Basic X-ray Circuit

## BEHIND AND AHEAD

You now have an understanding of what makes up your machine and how these devices work. Figure 2-41 is a complete diagram of a basic X-ray unit. You know about switches, fuses, voltage or line compensators, autotransformers, meters, rheostats and choke coils. You have an understanding of transformers and rectification. You know what an X-ray tube looks like and are aware of what is in it. You have not learned all that there is to learn about your machine yet, but, for now, you can say that your physics is behind you. Many things may have escaped you on the first reading. If they did, remember that these things are new to you and it will take time. Do not be discouraged if you have had difficulty. Go over the questions on the next few pages. These will help you to weld into your mind the essential knowledge that you will need. Go back and review for those questions you cannot answer. Many times when you are reading your eyes are on the paper but your mind subconsciously is on other things. Try to concentrate only on what you are reading.

Ahead of you is a chapter on electrical and radiation protection. Because you are working with radiation and very high electrical currents you must be fully aware of the dangers involved in their use. Properly used they can be controlled. However, carelessness allows X-ray and electricity to become deadly, violent enemies. You must learn how to protect yourself, your patient and those who work around you. Learn the next chapter well and observe all things it will tell you.

## REVIEW QUESTIONS

### HISTORY

1. Who discovered X-rays?

2. On what date were X-rays discovered?

3. In what country were X-rays discovered?

4. What type of rays was the discoverer of X-rays experimenting with when he noticed X-rays?

5. What did he see on the barium platinocyanide screen that made him know he was observing a new kind of ray?

6. What was one of the main factors in the serious development of X-ray?

7. What did W. D. Coolidge contribute to X-ray?

### X-RAY PHYSICS

1. Define - matter, energy, work, element and atom.

2. Diagram an atom of hydrogen.

3. What does the atomic number of an element mean? What does the atomic weight of an element mean?

4. What are electromagnetic wave radiations?

5. What does wavelength mean?

6. What does frequency mean?

7. What is a photon? Do all photons have the same energy?

8. What is an electric current?

9. What is an electric circuit?

10. What is a kilovolt? What is an ampere?

11. What four things determine the amount of resistance in a conductor?

12. Distinguish between an open and a closed circuit.

13. What is a series circuit? What is a parallel circuit?

14. What does resistance and amperage have to do with overloading a circuit?

15. What is magnetism? What are the three types of magnets?

16. What is magnetic induction?

17. What are electromagnets? What is electromagnetic induction?

18. What four factors determine the amount of current induced into a wire?

19. What is alternating current?

20. Describe how an alternating current generator works.

21. What is meant by single phase, 2 phase and 3 phase current?

22. What is direct current? Describe how a direct current generator works.

23. What is the line compensator used for on your X-ray machine?

24. What is the autotransformer used for in your machine?

25. What is a variable resistor? What is a rheostat?

26. Describe the principle of meters.

27. What is rectification?

28. Describe how the current travels in a four valve tube rectification system.

29. What is a cathode?

30. What is an anode?

31. What is a stator? What is a rotor?

32. Below is a list of devices that you should have learned. Place the proper letter, (a) for low voltage side, or (b) for high voltage side, in front of each device according to where you think each device is located. Then return to your basic diagram and see how many you have correct.

_____ 1. Pre-Reading Kilovolt Meter

_____ 2. Variable Resistor

_____ 3. Filament Transformer

_____ 4. Line Compensator Meter

_____ 5. Milliammeter

_____ 6. Valve Tube Transformer

_____ 7. Autotransformer

_____ 8. Timer

_____ 9. Line Compensator

_____ 10. Rectifiers

_____ 11. Major and Minor Kilovolt Selectors

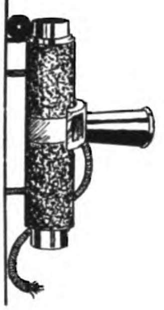
_____ 12. Switch

_____ 13. Ammeter

_____ 14. Resistor

_____ 15. Focusing Cup

_____ 16. High Tension Transformer



# CHAPTER 3

## ELECTRICAL AND RADIATION HAZARDS AND PROTECTION

Every technician who works in X-ray MUST BE AWARE OF THE DANGERS associated with electrical current and radiation. He is required not only to KNOW THEY EXIST, but do everything in his power to protect himself and his patients from harm. As an X-ray technician you must develop SELF DISCIPLINE AND ACCEPT YOUR RESPONSIBILITIES for protecting yourself and the people around you without constant direct supervision.

Properly controlled, electricity and radiation have proven to be wonderful tools in bringing man comfort and longer life. However, they possess the nature of turning on their masters when the master becomes careless or complacent. You must learn how to keep them as your servant and never allow them to become your master. You will not have fear of them, but have knowledge of them. As a technician in the field of X-radiation your knowledge of these must be very thorough because you will be putting this knowledge to practice in your daily work.

In this chapter you will receive explanations of terms used in protection and hazards, the types of injuries that can occur, sources of danger, procedures and devices used to protect you and techniques and devices used to detect possible radiation injury. Now let's begin with ...........

### ELECTRICAL HAZARDS AND PROTECTION

The hazard in electricity is electric shock. You have had an electric shock happen to you at sometime in your life from walking across the floor and then touching some object. You may have seen a spark jump from the end of your finger and felt a slight, disagreeable sensation run through your hand and arm. Generally, you are neutral. You are "grounded" so to speak. You're at zero potential. However, when you are working around electricity in an X-ray clinic you must realize that you are always at a lower potential than the current you are using. This degree of difference in potential may be as little as 50 volts or as great as 100,000 volts.

## SHOCKPROOF EQUIPMENT

Most modern X-ray equipment in operation in the Air Force today is shockproof. All parts of the machine that you are exposed to have been provided with a "ground" connection. GROUNDING is the connecting of a circuit to the earth by a wire which has a very low resistance. The electrical circuits of your X-ray machine provide for the grounding of various parts of the machine. If contact with the grounded portion of your machine is made, no current will pass through you because electricity will ALWAYS TAKE THE PATH OF LOWEST RESISTANCE.

ALL METAL CONDUITS, CONTROL PANEL, TRANSFORMER, TUBE AND TABLE AND ANY OTHER ELECTRICAL DEVICE WITH WHICH YOU COME IN CONTACT MUST BE GROUNDED. A good ground will allow enough current to open a circuit breaker or to blow a fuse. Generally these grounds are installed by maintenance men when your machine is first put into place. However, when working with field equipment or with a portable X-ray machine you must see that it is properly grounded. Periodic maintenance checks will insure that the ground connections have not been loosened or unattached.

You will notice that all the cables on your machine are very heavily insulated. These cables are high tension cables and are provided with a grounded sheathing which is covered by further insulation. Because of the very high currents carried by these cables they should be inspected frequently for breaks or cracks in the insulation. Breakdowns in these cables are a source of danger. If you should notice any breaks or cracks, notify your maintenance man for repairs or see medical supply for replacement. These should never be used "just one more time".

Although most of your equipment is "shockproof" you will have to make frequent checks to insure that it stays that way. Any device will not be as good as new after it has been used for a time. Always use CAUTION even with equipment that is shockproof.

## SOME PRECAUTIONS TO TAKE

DON'T operate equipment with wet hands. The darkroom is a source of danger when you attempt to work with an electrical device with wet hands or while you have one hand in the water. It is also important that you keep your darkroom floor dry. Observe the "one hand rule" - never turn on a device or plug in a connection with the other hand on a conductor. When your hands are wet and you turn on a device where the insulation is worn or the circuit defective, the current tends to go through you to ground instead of through the circuit as it should. It would be like standing in a bathtub in your own home and reaching to turn on a light.

NEVER severely bend or kink your high tension cables. The cable insulation and grounding may break and expose the wire. Electricity tends to collect at sharp points and if you come in close contact with the cable the current will have a tendency to spark toward you. Also electricity could discharge through the tube column of the machine and the table if the cable came in contact with them.

NEVER attempt to fix or adjust any part of your machine, like changing fuses, checking cables, or changing illuminating bulbs while the machine is in the "ON" position.

DON'T EVER ATTEMPT to repair, connect or adjust equipment in a machine with which you are NOT COMPLETELY FAMILIAR. Most all maintenance of your machine will be done by experienced maintenance men and commercial representatives. There are devices in your machine like condensers which could store or hold large charges of electricity even when the machine has been turned off for hours. If you touched or came close enough to them to cause them to discharge, you more than likely would no longer be among your friends.

Now with these general ideas you will want to know about what would happen if you became careless or someone else became a victim of .........

## ACCIDENTAL ELECTRICAL SHOCK

On the primary side of your machine and in most of the auxillary devices you will be using, you will find alternating current. You will also find alternating current in the transformers, but as it passes through the rectification system and into the high tension cables to the tube it will be direct current.

Alternating current is usually the most common type of current that is involved in electrical shock. This is true because it is the most commonly used current. A low voltage AC circuit is more dangerous than low voltage DC. However, a high DC is more likely to be fatal than a high AC. You will have low voltage AC in your controls, a high AC in your transformer secondary coil, and high DC in your cables and tube.

Low voltage with high amperage tends to hold you to the area of contact. High voltage and low amperage will throw you away from the contact. It does not take an excessive amount of amperage to hurt you. As you know now, we use milliamperage in X-ray. Four to twelve MA will only surprise you and not cause much discomfort, but forty to one hundred MA will cause your respiration to cease immediately. One hundred MA to one ampere is considered the maximum that you can safely stand. Any thing above that will cause damage to your heart which is often fatal.

The duration of contact is extremely important. The longer a person is held the less chance of survival. This is important to remember when you work around low voltage and high amperage. However, with a high voltage shock you will usually be thrown away by the violent contraction of the muscles and be freed quickly.

Because your nervous system operates in an electrical nature any outside influence, if sufficiently strong, can upset it. One of the most common effects of electrical shock is the temporary paralysis of various organs. If the organ paralyzed is the respiratory center, you stop breathing because the brain cannot get through to it. For this reason you must apply artificial respiration until this temporary paralysis is overcome. The most serious danger of shock is to the heart. The heart works on the principle of a tiny electrical system, so any outside interference may disrupt its action. The heart will not be hurt physically, but the mechanism of its function will be changed. When this happens no blood is pumped to the body and death can occur quickly.

SOME EFFECTS OF ELECTRICAL SHOCK. Electrical shock caused from high tension currents can cause severe burns. When contact of a body is made with high tension current a high temperature is generated by the resistance of that body and it burns up the tissue.

Fractures may occur from being thrown or by violent contraction of the muscles. If the victim is still conscious after the shock he may appear dazed. He may not be able to hear because of partial deafness so cannot respond to instructions. He will commonly have pain and soreness in his muscles. He may not be able to see well due to temporary visual disorders. A variety of other effects may be seen. Vomiting, delerium, and a depressed mental state are a few of the symptoms.

THINGS TO DO IN ACCIDENTAL ELECTRICAL SHOCK. First, LEARN WHERE ALL THE SWITCH BOXES ARE LOCATED AND THE FASTEST ROUTE TO THEM! Remember that the duration of contact can mean survival or death. Second, DO NOT LOSE YOUR HEAD! Grabbing a victim in contact with current is suicide. If you cannot get to a switch to turn the current off, remove him with a dry rope, cloth or other material that is not a conductor. DO NOT JUST STAND IN HORROR - MOVE!

Third, if the victim is still conscious and breathing KEEP HIM QUIET AND LYING DOWN. If he is unconscious and not breathing start giving him artificial respiration IMMEDIATELY. He must be kept warm. Also, a hard rap across the feet, over the heart, or on the back may serve as a countershock to get the heart back in action if it has been involved. Such action can do no harm and it may help.

Fourth, although it is done as soon as possible, CALL YOUR DOCTOR!

YOUR RESPONSIBILITY. You know now that your safety from electrical shock is UP TO YOU. You are aware of the necessity for constant alertness even with "shockproof" equipment. You should know some of the things you should never do. You are aware of the sources of various areas of danger. You know now about some of the effects of electrical shock and you know what to do in case of accidental electrical shock.

Ahead of you is a hazard that is more secretive and less visible than violent electrical shock. You will learn how radiation can effect you, the processes it uses in affecting tissue, how radiation effects are detected and what you must do to protect yourself. Go on now to ..............

## RADIATION HAZARDS AND PROTECTION

Any "ionizing" radiation is potentially dangerous if it is excessive. X-ray, radium, radioactive isotopes, and other radioactive material are your sources of radiation danger. They do not ring bells or shout their presence. Because you are going to be working day in and day out with these types of materials they are a constant danger to you. But before you go too far into the hazards or protection you must be able to answer the question .............

### WHAT IS IONIZING RADIATION?

To understand ionizing radiation you must be aware of what ions are. Do you remember that the atom has protons and electrons? An atom that is neutral will have just as many protons as electrons. An ion is an atom that is lacking an electron or one that has an electron it doesn't need. If an atom is missing one electron which it

is supposed to have, it will have an extra proton in the nucleus. This atom, then, will be a POSITIVE ION. If an atom has an extra electron that it doesn't need, then it will have one more negative charge than necessary. This atom is a NEGATIVE ION.

Atoms can be ionized by X-rays, gamma rays, alpha particles, or beta particles. The energy of an X-ray proton can remove an electron from the orbit of an atom and make that atom a positive ion. It can also cause an electron to be shoved onto another atom that doesn't need it and make that one a negative ion. When radiation causes both negative and positive ions to be produced you will have ION PAIRS. An ion pair is, then, a positive ion and a negative ion.

It is this physical ability to ionize atoms and form ion pairs that cause the biological radiation effects in your body. It is the amount of these ions and how they are distributed that determines the effect you will receive. This same ability of X-rays is used in measuring how much X-ray is present.

You will remember two of the properties of X-rays you had in Chapter II.

- X-rays cause ionization of gases.
- X-rays can kill or damage living tissue.

## RADIATION EFFECTS ACCUMULATE

EFFECTS OF IONIZING RADIATION ARE ACCUMULATIVE. This means that every time you receive any radiation the effects are added up. As an X-ray technician you MUST BE FULLY AWARE OF THIS FACT. Your body can take just so much radiation. Those portions that are irradiated DO NOT COMPLETELY REVIVE. This has to be clarified, however. If you X-ray your hand, some of the atoms of the hand are completely changed by the radiation. These atoms cannot be replaced. However, those atoms that have only been damaged may be able to fix themselves up again. It is like filling a bucket with water. After a day out in the sun some of it evaporates. You will be able to pour more water into the bucket to bring the level back up, but you will never be able to recover that water which evaporated. As long as you keep filling the bucket you can maintain its level, but if you can only put a little water in at a time you will not be able to keep up with the evaporation and your bucket will run dry. Radiation effects are similiar to this evaporation of water. If you keep on receiving radiation continuously the damaged cells have no chance to restore themselves, but keep on evaporating. Pretty soon this evaporation will run the body dry of life.

Now the question that should be in your mind is, "How much radiation can I receive without any ill effects?" This will bring you to the unit for measuring X-ray radiation.

## THE ROENTGEN

The "roentgen" is the unit of measure for X-ray and gamma radiation. The symbol for roentgen is "r".

The roentgen shall be the quantity of X or gamma radiation such that the asso-

ciated corpuscular emission per 0.001293 grams of air, produces, in air, ions carrying 1 esu of quantity of electricity of either sign (Figure 3-1).

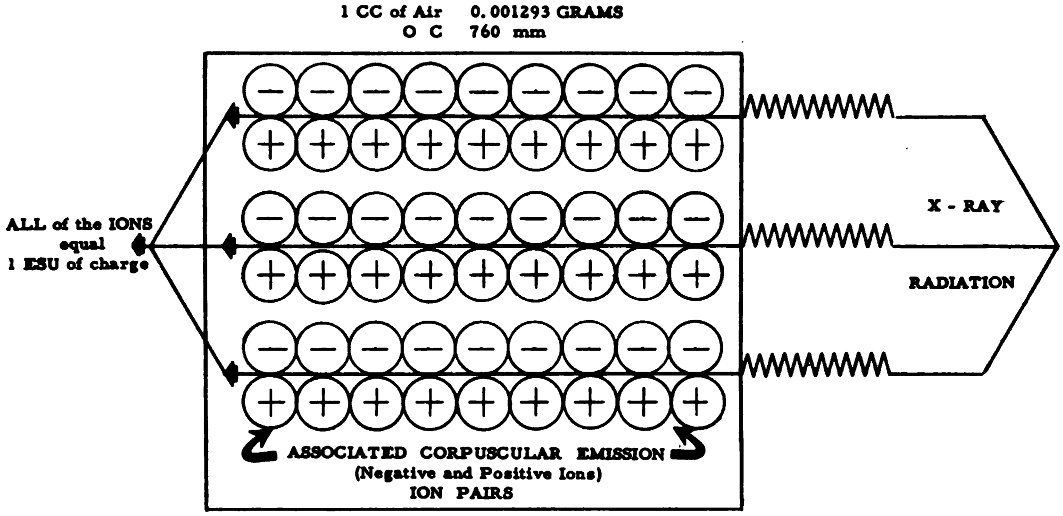



Figure 3-1 The Roentgen

This, of course, means very little to you at the moment. What it boils down to is that one roentgen of X-ray or gamma ray will in 1 cc. of air, produce negative or positive ions that carry an electric charge totaling 1 esu. An esu is a quantity of electric charge which, if placed in a vacuum bulb one centimeter from another charge of the same type and just as strong, will repel it with a force of one dyne. A dyne is the amount of force or shove which can accelerate a mass of one gram one centimeter per second. This will take a little study, but you should have some concept of the unit with which you will be working. You can look at it more clearly if you realize that an esu is just a smaller unit of electricity like the volt. To illustrate, take a bucket of beebees and throw them across a room so that they gain one volt of charge. The beebees could be the "associated corpuscular emission", (negative or positive ions), the room the 1 cc. of air and the one volt's worth of charge on the beebees could be the 1 esu charge of electricity. If you had only half a bucket of beebees you only get one-half of a volt so you would only have one-half of a roentgen.

Remember that the roentgen is the measurement of a certain amount OF X- OR GAMMA RADIATION IONIZATIONS IN AIR. The more X-ray present the more ionization in the air. Air is used because it has approximately the same atomic weight as the human body. At the present time there is no common practical means of measuring the amount of X-ray ionization within the body itself.

Now that you have some idea of what a roentgen is, you are interested in just how much you can safely receive. This amount is known as .........

THE MAXIMUM PERMISSIBLE EXPOSURE. The maximum permissible exposure is 0.300 r per week. As you see it is a great deal less than even one roentgen. This exposure to X-ray or gamma ray is set on the basis of a forty-eight hour week. You will see the symbol "mr" in many instances associated with exposure. This is an abbreviation for "milliroentgen" or one one-thousandth of a roentgen. Your maximum permissible exposure is 3/10ths of a roentgen or 300 milliroentgen per

week. This exposure is for WHOLE BODY irradiation. Whole body irradiation means that the entire body receives the exposure. Certain parts of your body can be exposed to more in some instances without ill effect. HOWEVER, YOU MUST BE AWARE AND UNDERSTAND THAT THE AMOUNT OF EXPOSURE THAT IS TOLERATED IS DIFFERENT IN VARIOUS PERSONS. You may be able to receive more than the permissible value without any visible changes, but another man may not be able to tolerate even that much. It has been shown that most X-ray technicians can work continuously around X-ray if he does not exceed the maximum permissible exposure.

The biological effects of radiation injury are seen by skin changes, changes in the blood or possible effects to the sexual organs. To avoid any of these effects you will have to be aware of the .............

SOURCES OF RADIATION EXPOSURE

Because you cannot see, hear, feel, touch or smell X-rays you must never ignore their possible presence. You cannot outrun them, unless you can travel 187,000 miles per second. You will have to know where to look for them even though your physical senses cannot help you. Your main sources of danger in X-ray is from the PRIMARY BEAM OR FROM SECONDARY RADIATION. (Figure 3-2).

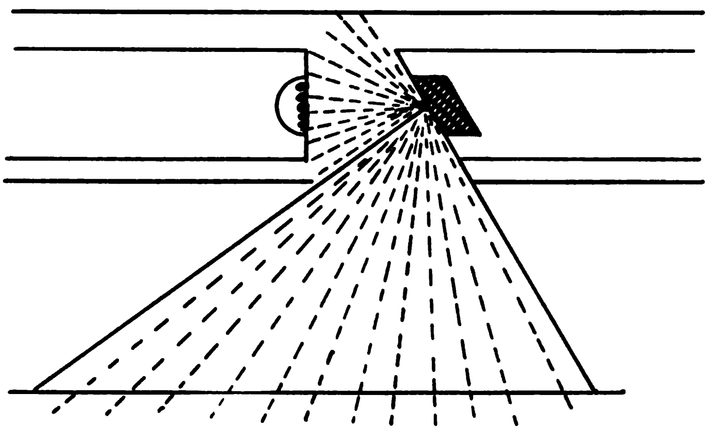

PRIMARY BEAM - DANGER !

Figure 3-2 Primary Beam

The primary beam is that beam of X-rays that is coming directly out of the tube head of your machine. YOU WILL NEVER STAND DIRECTLY IN FRONT OF AN X-RAY TUBE DURING AN EXPOSURE. You can receive your entire permissible exposure for a month in one tiny fraction of a second. You cannot FORGET and you must not become CARELESS.

Secondary radiation is radiation caused in any object that is struck by a primary beam of X-rays. As an X-ray strikes your body it will produce secondary radiation from the atoms it strikes in your body. In Chapter II the different energy levels of an atom were discussed. As an X-ray photon moves through your body and hits one of the atoms it can remove an electron. When this electron is removed there is

a release of energy which will have a different wave length than the X-ray photon that removed it. Also if one electron is removed from one energy level another electron from another energy level may move in to replace it. This will also release energy and this, too, will have an entirely different wave length. These other wave lengths will go off in all directions. Most of these will be longer wave lengths than the original and these long or soft wave lengths cause the most damage to your body.

Remember that secondary radiation can be produced by any object that is struck by X-rays. This means the patient, the tube, the table, the walls or any object in the path of X-rays can produce secondary radiation. Remember also that these secondary radiations can produce more radiation until all the energy is completely expended. One thing, however, is that this production of secondary radiation is over in an instant. These objects will not continue to emit radiation after the exposure is over. They do not become radioactive (Figure 3-3).

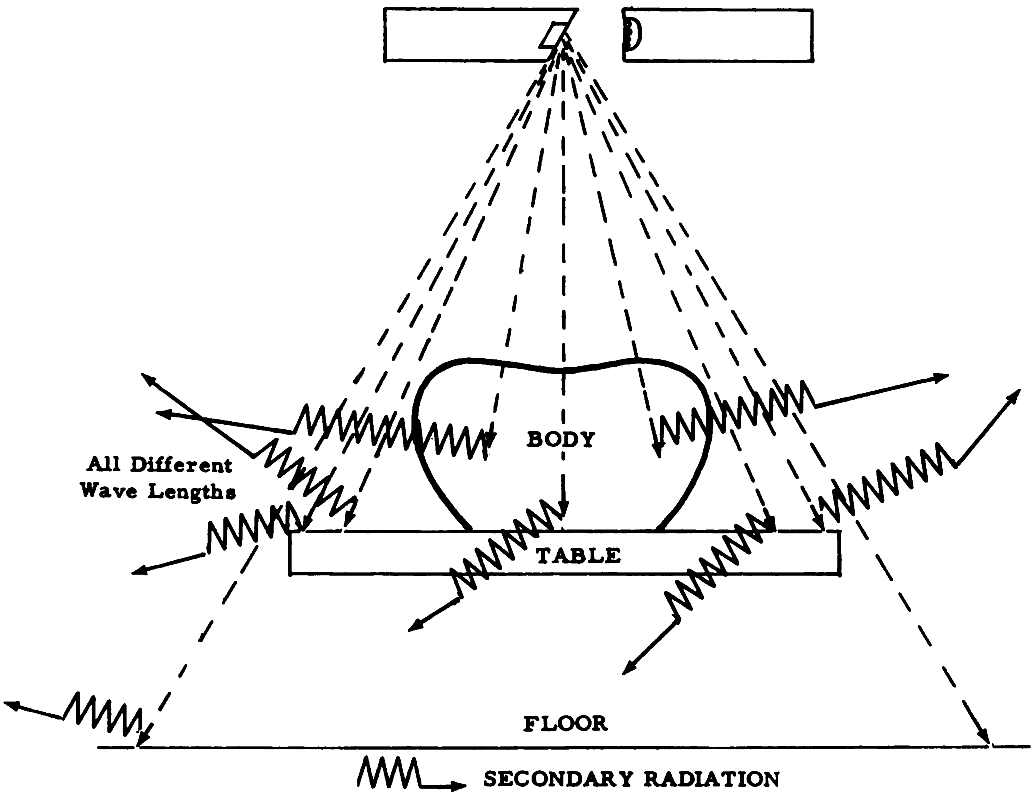



Figure 3-3 Secondary Radiation

The other sources of danger, like working with radioactive isotopes, radium and therapy, will affect you at some time or another, but they will be mentioned later in this manual. The question that comes up now is ............

## HOW TO PROTECT YOURSELF

There are a number of means of protecting yourself from radiation exposure. With protective devices, you need never be exposed to the maximum permissible ex-

posure dose. Even with these means available, IT IS UP TO YOU TO USE THEM WHENEVER AND WHEREVER IT IS HUMANLY POSSIBLE.

DISTANCE REDUCES THE AMOUNT OF EXPOSURE RECEIVED. To understand how distance protects, you will have to become more familiar with an X-ray beam. X-rays, as you know, come from the target of the X-ray tube. They spray off the target like water when you turn the hose nozzle down for a fine circular spray. Most of these rays are absorbed in the tube housing and only those going straight down are allowed to escape the tube. You will also remember two more characteristics of X-rays from Chapter II:

- X-rays always travel in straight lines.
- X-rays cannot be focused to a point.

The X-rays, then, that leave the tube travel in straight lines and spread out like a fan. Take a deck of cards, spread out a few of them as you do when you are holding a hand. Then imagine the edge of each card as being an X-ray. The point that you hold them with at the thumb could represent the target. As you can see the lines or edges diverge out from your thumb in straight lines. Now if you laid the cards down carefully on the bottom edge of a sheet of paper and took a pencil and carefully drew lines from each edge you would see that the longer you drew them the farther apart they would be and the greater area they would cover. If you place your hand at the top edge of the paper you could see that so many of the lines would pass through it. But the farther out you put your hand from the paper the less lines would pass through your hand. Finally, if you were far enough away, the only lines that would strike your hand would be those that came straight out from your thumb. This shows you that the farther away from a beam of X-rays you are the less X-rays you will have hit you. Also remember that as X-rays pass through the air they will lose some of their energy in ionizing that air. The more air they have to pass through the less powerful they become until they have so little energy left that they can't hurt you.

But do not get the idea that distance is everything. It is a big help but only one means of protection and is used WHEN THERE IS NO OTHER TYPE OF PROTECTION AVAILABLE. Distance will be explained in a further manner later on.

PROTECTION BY BARRIERS OR SHIELDING. A barrier is any material that will absorb X-ray and reduce the hazard of exposure. Materials such as lead, barium plaster, concrete, steel, etc., are barrier material. Lead is the most common material and it will stop most ordinary medical X-rays. However, it is heavy and expensive, but it is abundant and easily worked into sheets. Lead is also used as a standard for the amount of other material that is used. What this means is that other material has a LEAD EQUIVALENT. For example, if one inch of lead would stop all the X-rays generated by a 100 KV machine, then it would take twelve inches of solid concrete to do the same thing. This would make twelve inches of concrete EQUIVALENT in stopping power to one inch of lead. An inch has been used for example only. Generally, lead is used in millimeters of thickness (Figure 3-4).

The KV capacity of your machine determines the thickness of the barrier that is going to be used. (For information on construction, look at AFM 160-10).

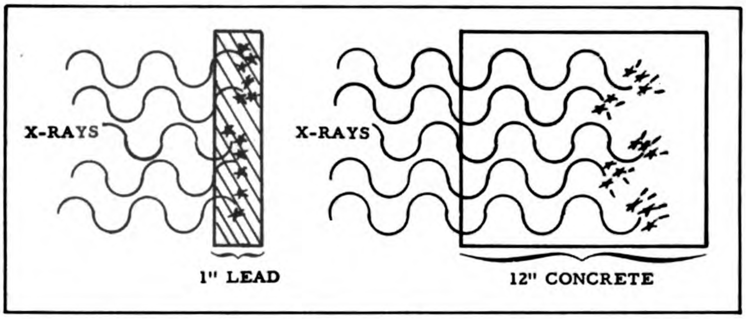



Figure 3-4 Example of Lead Equivalent

Barriers that you will be using may be of different types. THEY SHOULD ALWAYS BE USED WHENEVER AND WHEREVER POSSIBLE. A room that contains your control panel is a barrier. Or if you have no separate little cubicle for your control panel a shield in front of your control panel is a barrier. The window in these barriers is made of lead glass so it is a barrier too, but it allows you to see your patient. Lead rubber aprons and lead rubber gloves are a type of wearable barrier and WILL BE WORN if you have no other type. These are heavy and clumsy, but they are PROTECTION. It is a foolish technician who doesn't use them when there is no other barrier.

One thing to remember when using shields or barriers is STAY BEHIND THEM DURING AN EXPOSURE! They are of little use when you have your head or some other part of your body stuck out from them.

FILTERS ARE ANOTHER TYPE OF PROTECTION. They are used mainly for protection of the patient. Filters are sheets of different metals of various thicknesses used to absorb or filter out harmful long wave lengths. You will remember that the longer the wave length of an X-ray the less it will penetrate. Because a beam of X-rays has all types of wave lengths, a filter will stop most of the more harmful long ones. The technician is protected indirectly by the fact that these long wave lengths cannot get to the patient or equipment to cause additional secondary radiation.

The filter used in diagnostic X-rays is usually an aluminum sheet which is placed directly beneath the opening of the X-ray tube. Look at your machine and see if you can find it. There are other types of metal such as tin and copper that are used in therapy filters which you will learn more about in the therapy section. The thickness of filters is measured in millimeters. You will hear or read the term "so many millimeters of aluminum filtration, etc."

It is wise to keep in mind that any material which reduces the amount of X-ray than can reach an object can be considered a filter. The housing of the X-ray tube acts as a filter in this sense, although it is built to absorb all the X-ray that does not come through the window of the tube. Your X-ray tube has what is known as INHERENT FILTRATION. Inherent filtration is the filtration of the tube housing itself. The aluminum sheets that you have to place under the tube are used for EXTERNAL FILTRATION. It is recommended that at least 1.5 mm. of aluminum be used for external filtration. Your tube head has the "inherent filtration" or "built-in" filtration equivalent to 0.5 mm. of aluminum. This gives you a total of 2 mm. of aluminum filtration. Make sure that you have that amount of filtration in your tubehead each time you expose a patient.

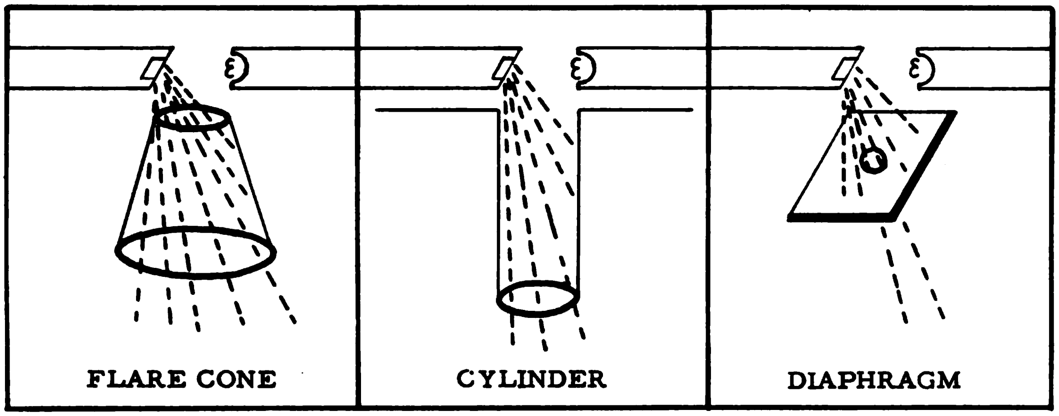



Figure 3-5 Cone, Cylinder and Diaphragm

CONES, CYLINDERS AND DIAPHRAGMS ARE ALSO USED FOR PROTECTION. The devices limit the area that an X-ray beam strikes. The spreading out of the beam is limited so that only a small part of it can strike the object. A cone is a flaring metal tube. It can come in many different sizes. The cylinder is also a round tube of metal, but it is built so it can be lengthened or shortened if desired. The diaphragm is usually a sheet of lead with round holes cut in the center. This restricts the a-amount of X-ray that gets out of the tube.

With the beam restricted to a smaller area the secondary radiation that is produced in the object is reduced. By reducing this secondary radiation you are reducing the amount of possible exposure, both to yourself and the patient. A CONE, CYLINDER OR DIAPHRAGM SHOULD BE USED DURING EVERY EXPOSURE. You will learn more about these devices in a later chapter also.

Putting all of this together you can see that you should be some DISTANCE AWAY FROM THE EXPOSURE, YOU SHOULD BE BEHIND SOME TYPE OF BARRIER, YOU SHOULD HAVE REDUCED MANY POTENTIALLY HARMFUL LONG X-RAY WAVE LENGTHS BY USING FILTRATION, AND YOU HAVE RESTRICTED THE X-RAY BEAM TO REDUCE THE AMOUNT OF SECONDARY RADIATION. If you DO all these things you will be sure of staying within your maximum permissible exposure dose. There will be times, however, that all of these protective measures are not available so use any of them that you have. However, just any barrier will not suffice. If it is not lead, which will stop any ordinary medical X-ray, it must be some material with a definite lead equivalent. Standing behind a panel of wood or plasterboard will not be sufficient. If you HAVE TO take X-rays without a barrier WEAR YOUR LEAD RUBBER APRONS AND GLOVES, GET AS MUCH DISTANCE BETWEEN YOU AND THE TUBE AS YOU CAN, RESTRICT THE BEAM WITH A CONE AND NEVER POINT THE TUBE SO THAT YOU WILL BE IN FRONT OF THE DIRECT PRIMARY BEAM.

Now even with all of these things in your mind you are wondering how you can tell if you DID receive any radiation and if so HOW MUCH. This brings you to .....

DETECTION OF RADIATION

If through carelessness or accidental exposure to radiation you have become exposed, how do you tell you have been exposed?

One method of checking an individual for overexposure is to take that individual's blood count. Your blood is sensitive to radiation. If your blood count reveals an excess of radiation you will be relieved of duty in the X-ray Section. You will be required to take a blood count at least every six months. Most departments or clinics that you will be working in will take blood counts from once a month to every three months. If you feel that you have been overexposed you should have a blood count taken.

FILM BADGES are a method of detecting and permanently recording the amount of exposure you have received. These film badges are little metal badges that have a special film in them. X-rays will expose the films. Periodically, these films are collected and developed. The amount of blackness on the film will determine the number of roentgens you have received. The device that is used to read these films is known as a DENSITOMETER. Your film is placed over a light and the amount of light that can be registered through your film tells you how much radiation you have received. The blacker the film the less light and the more radiation you have gotten. These badges should be worn every time you are working near or around X-ray. At clinics where facilities are not available for reading these films they can be sent or obtained from:

Environmental Health Laboratory Branch
Office of the Surgeon
Headquarters, Air Materiel Command
Wright-Patterson Air Force Base, Ohio

POCKET CHAMBERS are used in detecting radiation also. A pocket chamber is a device that works on the principle of ionization. It is a miniature ion chamber which is electrically charged. When X-rays are present the ionization of the air causes the pocket chamber to discharge. The amount of discharge of the chamber is recorded on a scale and you can read directly and immediately the amount of radiation you have received. These pocket chambers are small and shaped like a pencil so that they can be carried on your person. Because they have to be recharged, like a battery, every time they run down, they do not provide a permanent record of your exposure. Each exposure must be written down.

The DT-60 detector is being developed for use. It works on the principle of X-ray causing changes in chemicals. When exposed to X-rays it will change color or glow.

PHYSICAL DETECTION OF RADIATION. Because devices are man-made there is always room for errors. It is human nature to ignore these things that man cannot see, hear, or feel. It is not unusual for man to become exposed through carelessness or unwittingly exposed by accident.

In these cases, let's see what some of the actual visual effects of radiation exposure are. If there is overexposure the skin of the area involved will become red, much like a sunburn. The redness of the skin is known as ERYTHEMIA. The skin will become dry and scaly. Later it will start to peal or flake off. Ulceration or the appearance of sores that won't heal will follow. It is not pleasant and can, as far as you are concerned, be entirely avoided. There are few X-ray technicians today that are affected with any of these symptoms, because they USE PROTECTION. The men who have died in their study of X-ray have shown us what to avoid.

Another symptom of excessive exposure is the hardening and cracking of the fingernails. The nails will show signs of "ridging". This type of injury has usually been suffered by radiologists while fluoroscoping or by dentists who have insisted on holding the film in the mouth of the patient.

Symptoms of tiredness, lack of energy or loss of appetite can also suggest over-exposure to radiation. If this happens a blood count should be taken and a medical investigation made to see if it is caused by radiation.

RESPONSIBILITY FOR RADIATION PROTECTION. Officially the responsibility for the protection against radiation injuries is up to the medical officer in charge. He will set the standards and enforce them. In cases where it is felt that a monitoring survey should be made of your facilities, he will request it in accordance with AFR 160-67. However, the big job, the everyday job, IS YOUR RESPONSIBILITY.

You will keep as accurate records as you can on the exposure you have received. You will practice radiation protection at all times. Follow the rules that are listed below and you will receive little harm from radiation. You will have more of a chance of leaving this earth by overeating or smoking too much!

## PROTECTION RULES

- Never stand in the primary beam.
- Never make an exposure when another X-ray technician is in the room. Ask him to find protection.
- Never enter a room while an exposure is being made.
- Always wear protective aprons or gloves when you have no other barrier. Check the equipment frequently for cracks and breaks. Take an X-ray of them over a film. If they are not safe you can see it.
- Never hold a weak patient or kicking child yourself or ask another technician to do it. Use either the parents or a person who is not continually exposed to radiation. (Nurses, etc.)
- Always restrict the X-ray beam by a cone, cylinder or diaphragm.
- Always wear a detecting device while working in or around radiation.
- Always get as far away from a source of radiation as is physically possible to make your exposure.
- Never allow anyone to loiter in an area where there is possible danger of radiation.
- Always close doors that lead into other rooms where people are working or passing through.

- Always use filters in your machine.

- Never expose ANYBODY just for the fun of it. Do not take films without specific orders from the radiologist. Do not experiment on persons who work in X-ray.

- NEVER BECOME CARELESS OR COMPLACENT WHILE WORKING IN X-RAY.

PERSONAL HEALTH MEASURES. Because you are involved in a type of work that can be physically hazardous you must maintain a strong body. A good strong, healthy body will repair itself much more readily and you realize now that radiation can show more effect when the body is weakened and unable to recover itself rapidly.

The simple facts of personal health measures are:

- Eat regularly. A proper diet is required to give you building power.

- Sleep regularly. A body that is overtired is more susceptible to breakdown.

- Get the proper exercise. A technician should keep his body developed and in proper tone.

- Take regular leave, at least 21 days a year. Spend it out in the open.

- Take prompt care of illness, no matter how slight.

It is the simple process of taking care of yourself that can offset many harmful effects. It is not an easy thing to accomplish for many people, but for X-ray technicians it is very important to develop proper living habits. A technician who allows himself to become careless of his physical health should not work near radiation.

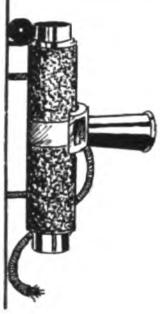
## BEHIND AND AHEAD

You should be prepared now to protect yourself and others from electrical and radiation hazards. There are still specific things you will learn about protection as you reach fluoroscopy and X-ray therapy, but you have the foundation. You know the sources of danger, have a concept of the roentgen, know how much radiation is considered safe for you, are familiar with the various detection devices, have an idea of the visible physical damage than can occur and MOST OF ALL WHO IS RESPONSIBLE FOR YOUR PROTECTION AND HEALTH.

Ahead of you is a chapter on the anatomy of the body. In this chapter you will learn how your body is made and how it works. An X-ray technician must be thoroughly familiar with the human body.

**QUESTIONS**

1. What must an X-ray technician do to protect himself and other people from radiation?
2. What does "grounding" mean?
3. What are high tension cables?
4. Why is the darkroom a source of danger?
5. What is the "one hand rule"?
6. Why is alternating current most generally involved in electrical shock?
7. Why is duration of contact with an electrical current important?
8. What is the common effect of an electrical shock to the organs?
9. If you cannot reach a switch to turn it off, how do you remove a man from a live circuit?
10. What is an ion? What is ionizing radiation?
11. What causes atoms to become ions? What is an ion pair?
12. Explain what happens when your body is subjected to radiation.
13. What is the roentgen? What is the symbol for the roentgen?
14. What does "maximum permissible exposure" mean?
15. What parts of the body show biological effects when exposed to radiation?
16. Where are your main sources of danger from X-ray? How do you protect yourself and your patient from these dangers?
17. What does "lead equivalent" mean?
18. What is a filter? How do filters work?
19. What do cones, cylinders and diaphragms do to the X-ray beam?
20. What are film badges?
21. What is a densitometer?
22. What are pocket chambers?



# CHAPTER 4

# ANATOMY AND PHYSIOLOGY

You are learning a job that no ordinary airman can perform. This job involves mastery of subject matter in various fields. In previous chapters of this manual you have learned something of the machine with which you will be working. You have learned some of the principles involved in the operation of this machine. You know that this machine will be used on human beings. It follows, therefore, that you must know the human body to perform your job. In many ways your body can be compared to a machine. It is made up of definite parts which perform definite functions in the running of that body. You must learn to recognize each bone, know its name, where it is located and how it relates to the entire human skeleton. You will learn a few of the major muscles that you will see on your films. You will know the various organs in the body, what they look like and how they work. Your body will no longer be a mystery to you. You will see it in all its complexity. You will be amazed at the precision of its design. You think at the moment that learning the human body is going to be a difficult task. You are the "machine" that you will be learning, and this, in itself, will make the job easy. Look at your hand. Now it is just a hand with fingers and a thumb. You see only skin and wrinkles. Later on you will see much more than this. You will see phalanges and metacarpals. The wrinkles will show you how to locate the heads of these metacarpals. But let us start from the beginning. Study each section carefully because you are going to construct the many parts of the human body into a whole LIVING THING. And as you study let your mind stay open to the miracle of this thing that is YOU.

## TISSUES

Tissues are made from tiny, individual cells. The cell is the smallest part of your body. There are different types of cells in your body that serve specific purposes. There are nerve cells, muscle cells, blood cells, and others. Cells that are alike and perform a specific function form tissues. The tissues form organs. The organs form the various systems of the body.

The type of tissue that is of primary interest to the radiology technician is the

connective tissue. There are a number of different types of connective tissue, but you will be interested mainly in two of these, cartilage and bone.

## CARTILAGE

Cartilage is a gristle-like substance. It is tough and firm. There are different types of cartilage, but you will be interested in the hyaline and fibrocartilage types more than the others. These are types of cartilage which cover the ends of the bones and are found in the spine. You have seen this type if you have ever eaten the drumstick of a chicken. This type of tissue cannot be seen on an X-ray film usually, but it is necessary that you realize that it is present and where it is found. This type of tissue makes up the bones of the young infant and is present throughout the growth of an individual to adult life. By knowing this fact you can adjust your techniques of exposure. As you progress through this chapter, you will find where you will encounter this cartilage tissue. The most important type of tissue to you as a technician is...

## BONE

The bone is a type of tissue which is hard because of deposits of calcium and phosphorus. In the bones of your body you have two types of bone tissue. One is a spongy or cancellated type of tissue and the other is a hard or compact type of tissue. Because all bones are porous the difference between these two types of tissue in the bone is a matter of how much space is between the partitions in the bone. Cancellated bone is found at the ends of the bones and as a narrow canal through the center of the bone. The compact bone tissue is found on the outside of the bone and along its middle section where it gives the bone rigidity and strength. The canal of soft spongy bone in the center of a bone is called the medullary canal. This soft cancellated type of tissue in the bone has a soft material between it which is called the marrow. Some of the cells of the blood stream are made in the marrow of the bone.

All the bones of the body are covered with a membrane called the periosteum. "Peri" means around and "osteum" refers to bone (Figure 4-1).

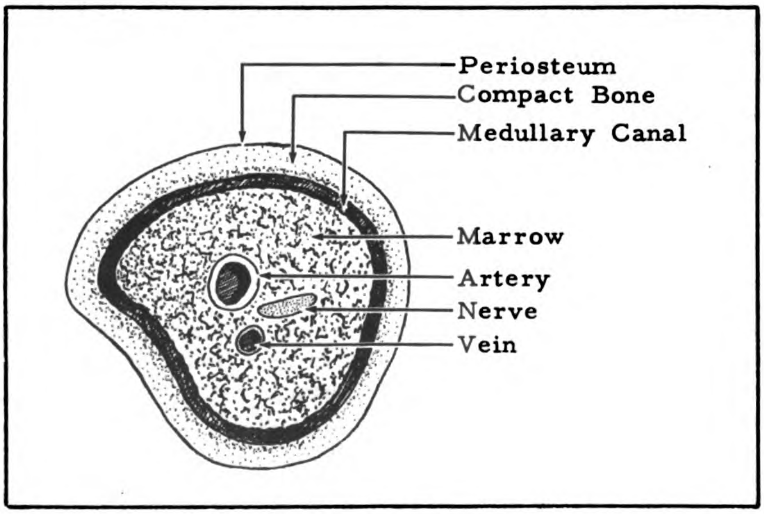



Figure 4-1 Bone Structure

In an X-ray you can see the different types of bone tissue. At the ends and in the center, the medullary canal, you can make out the partitions between the bony tissues. The space between them will be dark. Outlined along the outside of the bone you can see the compact bone as a white wall incasing the medullary canal. X-ray passes more easily through the spongy cancellous bone, but is stopped by the hard compact bone. As mentioned before, you will not be able to see the cartilage that covers the ends of the bone. Bone is well supplied with blood but cartilage is not.

OSSIFICATION. Bone is developed from cartilage. It grows from certain points in this cartilage and is called ossification. The points where this ossification begins are known as ossification centers. Because certain bones begin to form at different ages you can tell how old a patient is by the amount of ossification shown in the bones. Bones vary in the places where ossification begins. In the long bones of the body like the leg or thigh bones, it begins in the middle and at each end. The short bones, like the bones in the foot, begin ossification in the center and spread to the surface (Figure 4-2).

The area in the center, where the ossification begins in a long bone, is the diaphysis. Each end of the bone is known as the epiphysis. The bone ossifies from the diaphysis to epiphysis. It also ossifies from the epiphysis to the diaphysis. Meanwhile a thin strip of cartilage still develops between them until complete growth of the bone is completed. This strip of cartilage is known as the epiphyseal disc. On X-rays of adults it appears as a thin white line. It is then known as the epiphyseal line. On children's films it shows as a dark jagged line that resembles a fracture. Many of the bones are not fully ossified until you are twenty-one years old and some not until later. Because the cartilage at the ends of these bones do not stop X-rays they will appear to be fractures or breaks in the bones.

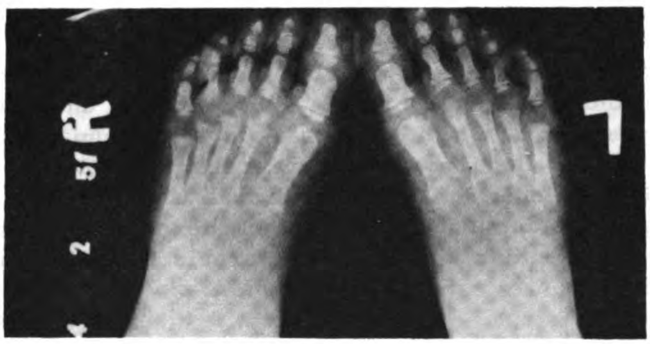



Figure 4-2 Bone Ossification

TYPES OF BONES. Bones are classified into four different types. These types are long, short, irregular and flat.

A long bone, which has been mentioned, has a shaft (diaphysis) and two extremities (epiphyses). The shaft is composed mostly of compact bone tissue with the center occupied by the cancellous tissue and the marrow. The center, as you know, is the medullary canal. The thigh bone (femur) and the arm bone (humerus) are examples of long bones.

The short bones are usually irregular in shape. They are spongy on the inside

and have a hard compact bony surface. The bones of the wrist and of the foot are examples of short bones.

The irregular bones are bones which have an odd shape. They have a spongy center and a compact covering also. The vertebrae in the spine and the bones in the pelvis are examples of irregular bones.

The flat bone is the type found in the skull. It has a spongy center and compact bone on either surface resembling a sandwich.

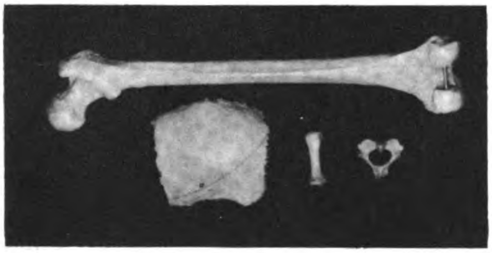


Figure 4-3 Types of Bones

## JOINTS

All the bones of the body meet with other bones. There are three main types of connections which are known as joints or "articulations". An articulation is where two bones join together.

These joints or articulations are named for the amount of movement they allow. Immovable joints are known as synarthroses. "Syn" means union and "arthroses" means joints. The type that is slightly movable is the amphiarthrosis. "Amphi" means around or about. The last type, which is freely movable, is the diarthrosis. "Dia" means across or between. The bones of the skull are of the immovable or synarthrosis type. The spinal column is an example of the amphiarthrosis type, having a limited motion and the shoulder joint is a diarthrosis type of articulation, having a wide range of motion.

## ANATOMICAL TERMS

To learn the body and its parts you must learn some descriptive words or terms. These terms must mean the same thing to everyone as far as is practicable. These terms will tell about location, position, movement, arrangement, etc. These terms are used in reading the body just as you read symbols on a map. When you say "turn left at the next corner where the red filling station is and it is the third house on the right up the street", you can follow these directions easily and find the house you want. You want to know if something is located in a specific place; if it is up or down, right or left, how it is standing, if it faces the street or the alley, etc. You want to

know definitely what building you are looking for, the Old South Life Building, Base Headquarters, Joe's Grill and Beverage Parlor or 522 East Second Street.

You must use something of the same system in describing and locating the parts of the body in anatomy. The only thing different is that the names will be new and you will be finding places in your body. You will find that it isn't hard. Let us go on to a few basic terms you will need to get started. Be sure that you know them before you go on.

- NORMAL ANATOMICAL POSITION. When describing the body structures you consider the body to be in a standing position, arms at the sides, hanging down and the palms of the hands turned fully toward the front.
- ANTERIOR. Closer to the front of the body.
- POSTERIOR. Closer to the back of the body.
- LATERAL. Away from the midline of the body.
- MEDIAL. Toward midline of body.
- PROXIMAL. A point nearest the head.
- DISTAL. A point farthest from the head.
- SUPERIOR. Above.
- INFERIOR. Below.

Now that you have a basis on which to begin your study of the individual bones of the skeleton, let us take a look at some other terms you will use.

## TERMS USED IN OSTEOLOGY

Just as you find the Rocky Mountains as projections from the earth's surface and the Grand Canyon as a depression in the earth's surface, so can you find projections or depressions in the bones of your body. And just as you find cracks in the ground you will find slits or fissures in the bones. You have seen drainage tunnels under roads and ditches alongside them. You will see anatomical ditches and tunnels in the bones of the body.

The projections on the bones are called processes. There are different sizes and shapes of processes just as there are different sizes and shapes of hills and mountains.

- Process - a bony prominence which arises from the surface of the bone.
- Spine - a sharp, slender process of bone.

- Tubercle - a small rounded process.
- Tuberosity - a large rounded process.
- Trochanters - two processes below neck of the femur.
- Condyle - a rounded process on the end of a bone; bony knuckle.
- Crest - a ridge on a bone, round or sharp.
- Head - a round part of a joint resting on a "neck".

The depressions on a bone are called fossae. There are different types and they will vary in depth and length like the furrows and low areas in a field.

- Fossa - a depression in a bone.
- Groove - a ditch-like depression in a bone.

You will also find holes, canals, and cavities in the bones. These can be likened to an irrigation pipe in a field.

Holes are known as:

- Foramen - a hole through a bone for passage of nerves and blood vessels.
- Fissure - a slit in the bone formed by two adjoining bones.

Canals are known as:

- Meatus - a passage or opening.

Cavities are known as:

- Sinus - a recess, cavity or hollow space.
- Antrum - cavity or chamber.

If you know what these terms mean you can go ahead and learn about the individual bones of the human skeleton.

## THE SKELETAL SYSTEM

There are 206 bones in the human body. Any one of these bones can be broken or diseased. A radiology technician must be able to find them and show them on a film. Many of these bones have specific parts on them that are injured or diseased and you must know where these are on the right bone. However, the job of learning the bones is really cut in half; because you have two sides you need only to learn what is in one leg or one arm. You will have the same bones in the other leg or arm. All you have to do is say right or left. The preliminaries are over so here you go into the .................

## UPPER EXTREMITY

The upper extremity extends from the tip of your fingers to the shoulder bones. It contains thirty-two separate bones, or in both right and left upper extremities, a total of sixty-four bones. Each upper extremity has one hand, one wrist, one fore-arm (bones below the elbow), one elbow, one arm (bone above the elbow), and one shoulder.

HAND. The hand contains fourteen phalanges. These phalanges make up your fingers and thumb. Each finger has three separate phalanges. Those phalanges at the end of your finger are known as the distal phalanges (A). The ones in the center are the middle phalanges (B), and the ones that connect your fingers to your hand are the proximal phalanges (C). The thumb, however, only has two phalanges. These are the distal and proximal phalanges. Look at your fingers. Bend them. Do you see the three sets of creases? Beneath these creases are the joints between the phalanges. These joints are called interphalangeal joints. The joint where your proximal phalange connects to the palm of the hand is known as the metacarpophalangeal joint.

The phalanges of the fingers and thumb are connected to the metacarpal bones. Because you are studying the body in the "normal anatomical position", the metacarpals are directly beneath the palm of the hand. There are five of them. They are numbered. The metacarpal that joins the thumb is 1, the index finger is 2, the middle finger is 3, the ring finger is 4, and the little finger is 5. You see that you are counting them from the lateral side to the medial side. Now these metacarpals have a shaft and two extremities. Turn your hand over so you can see the back. Run your finger over the back of your hand and you can feel the metacarpals. When you double up your fist you see your knuckles. These knuckles are the heads of the metacarpals. They are known as the head of the third metacarpal, etc. You will notice that they are at the distal extremity. At the proximal extremity or where the metacarpals connect to the wrist is the base of the metacarpals (Figure 4-4).


Figure 4-4 Hand - PA View

So now you know that the hand has nineteen bones; fourteen phalanges and five metacarpals. Each finger has three phalanges; distal, middle and proximal, and that the thumb has just two, a distal and proximal. You know how the metacarpals are numbered and you know that each has a shaft, a head and a base. You also know that the bases articulate with the wrist.

WRIST. The wrist is made up of eight bones. These bones are known as carpal bones. The bones are arranged in two rows. These rows are the distal row which articulates with the metacarpals and the proximal row which articulates with the forearm. There are four bones in each row and each bone has a name. The bones in the distal row from the thumb side to the little finger are the greater multangular (A), lesser multangular (B), capitate (C), and hamate (D), as shown in Figure 4-5.


Figure 4-5 Wrist - PA View

The multangulars get their name from the number of angles they present for articulation and their size. The capitate is the biggest bone in the wrist. The hamate is named because it has on its anterior surface a bony hook which is known as the hamulus process. Hamulus means "little hook".

Look at the anterior surface of your wrist. You will see three transverse creases on the skin. Just distal to the distal crease you can find these four bones. The greater multangular comes off the first metacarpal base, the lesser multangular articulates with the second metacarpal base, the capitate with the third and fourth metacarpal bases, and the hamate forms a joint with the fifth metacarpal base. Just spread your fingers out and run a finger down each one to the locations.

The bones in the proximal row of carpal bones from the thumb side to the little finger, are the navicular (E), lunate (F), triangular (G), and pisiform (H). The navicular and the lunate are the only bones of the wrist which articulate with the forearm. The triangular and the pisiform are separated from the forearm by a small plug of cartilage. The navicular is a boatshaped bone and derives its name from its shape. It is also the bone which is most likely to be fractured in the wrist. The lunate is a half-moon shaped bone and also derives its name from its shape. Because of its shape and central position in the wrist it is the bone of the wrist which is the most frequently dislocated. The triangular bone gets its name from its shape, too. The pisiform is a little round bone that is located on the anterior surface beneath the triangular. ("Pisi" means pea so the bone is named for its shape just as the others.)

You can find these bones in the following ways. Extend your fingers out and forcefully spread your fingers. Now turn your hand over so you can see it from the thumb side. You will notice that the two visible cords that are attached to the base of

the thumb have a depressed triangular area between them. The space is known as the anatomical snuffbox. In that area you will find the navicular. The lunate can be found by following the fourth metacarpal down the palm to the center of the second transverse crease on the wrist. You can feel the pisiform on the medial side of the wrist like a hard little ball. It is in line with the fifth metacarpal.

Move your wrist around. You can move it quite a distance up and down, but not so far from side to side. The wrist is a gliding type of movable or diarthrosis joint.

## FOREARM

There are two bones in the forearm. They are long bones so they have a shaft and two extremities. These bones are the radius and the ulna. Turn your hand so the palm is up. The radius is the bone on the lateral side of your forearm. It is always on the thumb side even if you turn your forearm over so your palm is down. It is your radius that rotates over your ulna. The ulna is stable. The ulna is the bone on the medial side of the forearm.

THE RADIUS. The radius is somewhat triangular-shaped in its lower two-thirds, but as you go up to the proximal end (toward the elbow) it becomes rounded. It curves slightly as it goes up to the elbow, too. There are a number of structures on the radius that you should recognize. They are the styloid process (A), the ulnar notch (B), the interosseous crest (C), the radial tuberosity (D), the neck (E), and the head (F), as shown in Figure 4-6.

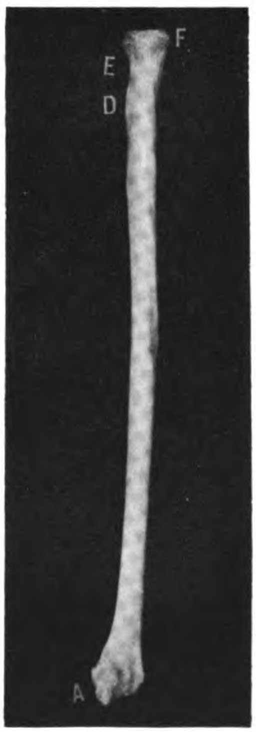




Figure 4-6 The Radius - AP and Lateral Views

The styloid process is located on the lateral side of the distal end of the bone. It is a pointed projection which forms part of the hollow at the end of the bone in which the navicular articulates. If you will make another "anatomical snuffbox" and feel with your thumb right at the base you will be feeling the radial styloid process. It is not as pointed as others you will learn about. On the medial side of the radius is a shallow, triangular-shaped notch, the ulnar notch. The lower end of the ulna fits into this notch and articulates with the radius. Roll your arm slowly and watch it. Can you see how this notch works?

The interosseous crest is found on the medial side of the radius extending up two-thirds the length of the bone. It is a sharp ridge and is the place of attachment of the interosseous membrane. This membrane is a help in directing any physical stress on the hand to be passed up to the shoulder, as when you fall on your hands the force is passed on up to the shoulder. If this action did not occur your arm might not be able to take the force and it would break the bone.

The radial tuberosity is a rather large rounded process or bone bump on the medial side of the upper end of the radius. You can see it very well on radiographs. It is used for attaching muscles. Just above this tuberosity the bone pinches in or "restricts" itself. This is known as the radial neck.

Because a neck usually has a head on it you'll find that just above the radial neck is the radial head. This head is round with a flat ridge running around it. This ridge spreads out a little on the medial side so that it is wider from top to bottom. Because of this it articulates with the ulna at the proximal end. The top of the head is not round like the other heads you will encounter. It is scooped out a little, or as anatomists say, it presents a concave depression. This depression is used when you bend your forearm at the elbow to touch your shoulder. The radius rolls up over a part of the arm bone. You can feel the radius in its lower two-thirds, but after you pass the middle section it is hidden under heavy muscle of the forearm. See how much of it you can feel. You should also notice in the radiographs that the radius is shorter than the ulna.

THE ULNA. The ulna is the medial bone of the forearm. It is stable and does not rotate. It is a long bone with a shaft and two extremities. It is small at the distal end and becomes larger as you proceed up to the proximal end. It is also slightly curved. The structures on the ulna that you must be able to recognize are the ulnar styloid process (A), head of the ulna (B), the interosseous crest (C), the coronoid process (D), the semilunar notch (E), the olecranon process (F) and the radial notch (G) as shown in Figure 4-7.

The ulnar styloid process is located on the distal end of the bone, near the radial styloid process. However, this ulnar styloid process is more pointed and is found on the posterior surface of the bone. You can see it very easily on a radiograph of the forearm. You will also see that it does not touch the triangular or the pisiform of the wrist directly.

The head of the ulna is at the distal end of the bone where in the radius the head was located at the proximal end. The head is the area on which the styloid process projects.

Just as the radius has an interosseous crest on its medial side the ulna has an interosseous crest on its lateral side. This makes the opposite connection for the interosseous membrane.

On the anterior surface of the bone, just below the gouged out section, at the proximal end, is a sharp, wide process known as the coronoid process. Look at the illustration of the ulna and find the coronoid process. In an X-ray you cannot see it except as a dense white line in the anterior position, but in the lateral position you can see it. This process is used for connecting a muscle of the arm.

The semilunar notch is that gouged out area on the proximal end of the ulna. It is this notch in the ulna that helps make up the elbow joint. You will notice that it is on the anterior surface of the bone. When you can see the semilunar notch, you should know that you are looking at the front or anterior side.

The part of the bone which is proximal to the semilunar notch is the olecranon process. This process forms the superior and part of the posterior portions of the ulna. Bend your elbow. Feel the point of your elbow. This is the olecranon process you are feeling. Now at your wrist you will feel and see a little round bump on the medial side of your forearm. This little round bump is the head of the ulna. Start at the head of the ulna, turn your arm in the normal anatomical position and run your finger up to your elbow. You will notice that you can feel the ulna all the way up. Also circle your forearm in the center with the fingers of the opposite hand. Rotate your hand so that you have the palm up and then down. Remember that you have to work with your mind in picturing these structures under the skin. You will not be able to peel off the patient's skin when you are working with him.


**Figure 4-7 Ulna**

You should know now what the bones of the forearm look like and you should be able to touch and identify a few of these structures. If you have just read this mate-

rial so far and have not actually performed the various things you have been directed to do, go back over the material, look at the illustrations AND USE RADIOGRAPHS OF THESE PARTS AND YOUR OWN BODY as training aids. And if you have forgotten, you are using the normal anatomical position in studying this anatomy.

HUMERUS. The bone of the arm is the humerus. It is a long bone. It has a shaft and two extremities. The lower extremity fans out into a triangular shape and its structures complete the formation of the elbow joint with the radius and ulna. The upper extremity is rounded and is part of the shoulder joint. On the lower extremity of the humerus you must know the CAPITELLUM (A), TROCHLEA (B), MEDIAL (C) AND LATERAL (D) EPICONDYLES, RADIAL FOSSA (E), CORONOID FOSSA (F), OLECRANON FOSSA (G) AND THE SUPRACONDYLAR RIDGES (H).

The capitellum is a round ball-like process on the lateral anterior surface of the humerus. It is on the capitellum that the head of the radius articulates. Just above or superior to the capitellum is the radial fossa. The edge of the head of the radius fits into this fossa or depression when the elbow is bent up.

The trochlea is separated by a ridge from the capitellum and is the structure on the medial side. This structure fits into the semilunar notch of the ulna. Just above the trochlea is the coronoid fossa. The tip of the coronoid process of the ulna fits into this fossa when the elbow is bent up. You can see now that when you have a process that is involved in a joint that you have a fossa for it to fit into.

The olecranon fossa is located on the posterior surface of the bone. It is a larger depression than either the radial or coronoid fossa. This is because the olecranon process on the ulna is much larger and deeper. If you will bend your elbow just part way and feel just above the tip of the elbow in back you will be able to put your finger into the olecranon fossa. When you put your arm straight out the olecranon process will fill the fossa and you can't feel it. You cannot feel those fossae on the anterior surface because the muscles cover them. You can see the olecranon fossa on a radiograph as a darker spot on the lower end of the humerus.

You now have all the bony structures that are involved in the elbow joint. These are the head of the radius, the capitellum and radial fossa on the humerus, the semilunar notch of the ulna, the trochlea and coronoid fossa of the humerus, and the olecranon process of the ulna and the olecranon fossa of the humerus. The trochlea and semilunar notch provide the elbow with a HINGE TYPE of movable joint. It is through this articulation that the force of a fall is transferred up the arm.

The supracondylar ridges are rounded ridges running from each epicondyle up toward the center line of the bone. Some of the muscles of the forearm begin at the supracondylar ridges and epicondyles.

The shaft of the humerus is round and only one structure you need to know is present on it. That is the DELTOID TUBEROSITY (I). It is located on the lateral side at the junction of the upper and middle third of the bone. It is the place where the deltoid muscle is fastened.

The medial and lateral epicondyles are located above and to the sides of the trochlea and capitellum. The medial epicondyle is the larger of the two. Feel your "crazy bone". The knob that you are feeling is the medial epicondyle. The lateral epicondyle is located across from the medial bone but is not as large or prominent.

The proximal end of the humerus has the HEAD (J), ANATOMICAL NECK (K), GREATER (L) AND LESSER (M) TUBERCLES, BICIPITAL GROOVE (N) AND THE SURGICAL NECK (O).

The head is rounded and is located at the superior and medial part of the upper end of the humerus. It is always directed medially. Just below the head is a constricted indention that runs around the head; this is the anatomical neck.

The greater tubercle is located just below the anatomical neck on the lateral side of the humerus. It is the larger tubercle. The lesser tubercle is located on the anterior surface of the humerus directly across from the greater tubercle. The two tubercles are separated by a deep groove which is the bicipital groove. This groove is used by a part of the biceps brachii. Just below the tubercles and the bicipital groove you will find another slightly constricted area. This area is known as the surgical neck of the humerus because this area is frequently fractured.

You should now know what structures you will find on the humerus and where they are located. You will always be able to tell which side of the bone is anterior and posterior because the olecranon process is on the posterior surface and the lesser tubercle is on the anterior surface along with the capitellum and trochlea. You will also be able to tell which humerus you have; a right or left by the way the head is directed medially and because of the very prominent medial epicondyle. You will not be able to feel the structures of the upper end of the humerus too much because of the heavy muscles in the area. The humerus is the biggest and longest bone in the upper extremity.

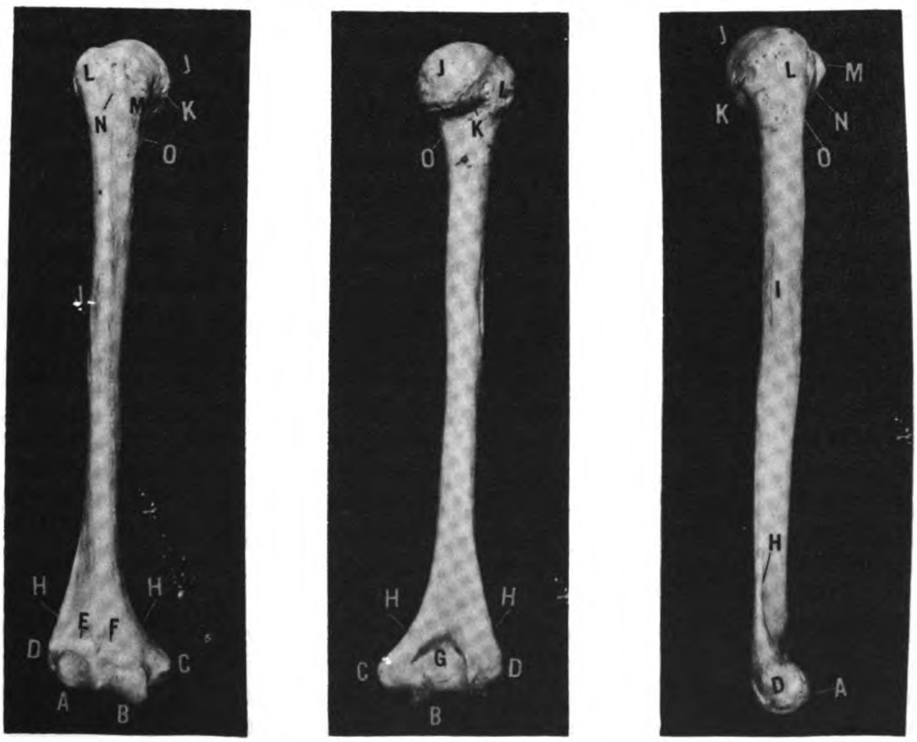



**Figure 4-8 Humerus - AP, PA and Lateral Views**

SHOULDER GIRDLE. The shoulder girdle is made up of the proximal end of the humerus, the scapula and the clavicle.

The Scapula. On the scapula (shoulder blade) you will find a number of structures. They are the GLENOID FOSSA (A), ACROMION PROCESS (B), SCAPULAR SPINE (C), CORACOID PROCESS (D), SCAPULAR NOTCH (E), SUPRASPINATOUS FOSSA (F), INFRASPINATOUS FOSSA (G), VERTEBRAL BORDER (H), INFERIOR ANGLE (I), AND THE AXILLARY BORDER (J). The scapula is flat, triangular bone on the back of the shoulder (Figure 4-9).

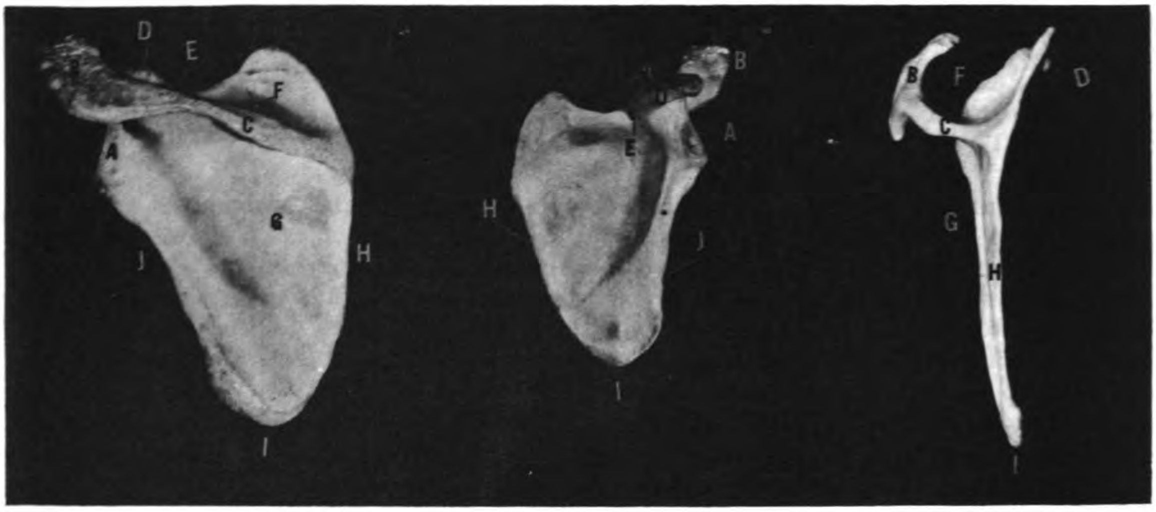



Figure 4-9 The Scapula - PA, AP and Lateral Views

The glenoid fossa of the scapula is located on the lateral side of the bone. It is dipped out slightly like the radial head, and this is where the head of the humerus articulates with the scapula.

The scapular spine begins from the medial posterior surface of the bone. It runs diagonally up and laterally, and the lateral end of it spreads out into an oblong process known as the acromion process. Above the spine, as it runs through the scapula is a large depression that is the supraspinatous fossa (supra means above; above the spine). And below the spine is the infraspinatous (infra means below; below the spine.). The infraspinatous fossa covers about two-thirds of the bone.

Anterior to the spine, and just above the glenoid fossa and slightly medial to it, is the coracoid process. It is a hook-like process that juts out anteriorly and laterally. At the base of the coracoid process and medial to it is a notch that is known as the scapula notch.

To understand the borders and angle of the scapula you must realize that it is placed in the body like an inverted triangle. The peak or apex is facing down toward the feet. This peak of the scapula is known as the inferior angle of the scapula. The sides of the triangle are the borders. The side or edge of the scapula that is next to the spinal column is the vertebral border. The side next to the armpit or axilla is the axillary border.

There are a number of these structures that you can see or feel. The acromion can be felt as the hard bony point on the top of your shoulder. You can see the outline of the vertebral border, the inferior angle and you can feel the axillary border to some extent. The scapula lays over the ribs in the normal position, but you can place your arm across your body and grasp the opposite shoulder with your hand and it will be moved to the lateral side of the rib cage. It is in this position that you can see the prominent vertebral borders. You can also feel the spine if you run your fingers across it.

The Clavicle. The clavicle is the last bone that helps to form the shoulder girdle. It is shaped like the italic "F". You can see it and feel it as the "collarbone". The lateral end (A) of the clavicle is the acromial extremity and articulates with the acromion process of the scapula. This articulation is known as the ACROMIOCLAVICULAR ARTICULATION. The medial end (B) is known as the sternal extremity. It articulates with the sternum or "breastbone". On the inferior surface of the clavicle near the acromial end, is a tubercle. This tubercle is the CORACOID TUBEROSITY (C). It is directly over the coracoid process and there is a ligament fastened between them which holds the acromioclavicular articulation together (Figure 4-10).

You know what the shoulder girdle is made up of now. The head of the humerus, the scapula with its glenoid process, the acromion process and the acromial end of the clavicle which form the roof, makes up the shoulder joint. This joint is very free in movement and is known as a BALL AND SOCKET type of diarthrosis joint.

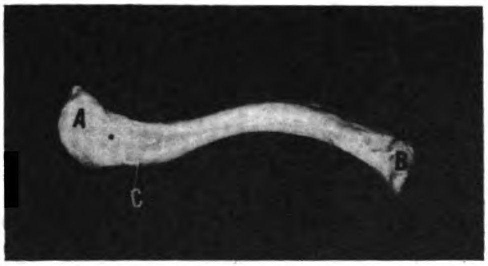



Figure 4-10 The Clavicle - Inferior View

You have now gone through the skeleton of the upper extremity. It has included fourteen phalanges, five metacarpals, eight carpals, one radius, one ulna, one humerus, one scapula and one clavicle. You know the structures that make up the finger joints, the wrist, the elbow and the shoulder joints. You know what order these bones come in and have an idea of where they are located. You have felt and seen many of these structures.

You should be ready now to go on to the lower extremity.

## LOWER EXTREMITY

The lower extremity has one foot, one ankle, one leg (bones below the knee), one knee, one thigh (bone above the knee) and one hip. There are thirty-one bones in each lower extremity.

FOOT. The foot has fourteen phalanges just as the hand. The four toes have

three phalanges; the distal (A), the middle (B), and the proximal (C). The great toe has only two as in the thumb, distal and proximal. The foot, however, has five METATARSALS instead of metacarpals. Also they are numbered just the opposite to those in the hand. You start from the medial side of the foot and count laterally. The metatarsal that articulates with the great toe is 1, then 2, 3, 4 and 5. You can easily feel these metatarsals through the top of your foot. The top of your foot is known as the DORSUM. The bottom of your foot or the sole is known as the PLANTAR surface. The foot does not have a wrist-type joint, but it does have seven bones that compare to eight carpal bones in the wrist. These bones in the foot are known as TARSAL BONES. They are the CUBOID (D), FIRST CUNEIFORM (E), SECOND CUNEIFORM (F), THIRD CUNEIFORM (G), THE NAVICULAR (H), CALCANEOUS (I), AND THE TALUS (J) as shown in Figure 4-11.



Figure 4-11 The Foot

The cuneiforms get their names from their wedgeshapes. They are called first, second, and third because they articulate with the first, second and third metatarsals. If this is the case, then, the first cuneiform is on the medial side of the foot and articulates with the base of the first metatarsal, distally. The fourth and fifth metatarsals articulate with the cuboid bone. The cuboid bone is an irregular oblong-shaped bone on the lateral side of the foot. The navicular is on the medial side of the foot and articulates with the three cuneiforms in front and with the cuboid on the lateral side. In back it forms an articulation with the talus.

The calcaneous (os calcis) is the largest bone in the foot. It is the heel bone and you can feel it very easily. It articulates with the cuboid in front. On top of the calcaneous is the talus. The talus is the bone that is part of the ankle joint. It articulates in front with the navicular and on its bottom with calcaneous.

It is important for you to see and realize the triangular shape of the foot. The joints between the tarsal bones will not be straight up and down but angled slightly away from the ankle joint toward the toes (Figure 4-11).

The ankle joint is made up of the talus bone of the tarsals and the lower or distal ends of the tibia and fibula. The joint is sometimes referred to as the ankle mortise because it resembles the mortise joints that are used in carpentry. It is an area frequently involved in injury. You will go on now to the leg.

THE LEG. The leg is the forearm of the lower extremity. It contains two bones. The bone on the medial side of the leg is the TIBIA. The bone on the lateral side is the FIBULA. The leg, as you know, has no rotating ability such as you find in the forearm.

<u>The Tibia.</u> The tibia is the largest and strongest bone in the leg. It is a long bone. It has a shaft and two extremities. It is triangular in shape through the shaft, but spreads out on each end. The enlargement is more noticeable on the proximal extremity.

The structures you must know on the tibia are the MEDIAL MALLEOLUS (A), ANTERIOR CREST (B), INTEROSSEOUS CREST (C), TIBIAL TUBEROSITY (D), MEDIAL (E) AND LATERAL (F) CONDYLES AND THE INTERCONDYLOID EMINENCES (G).

The medial malleolus is located on the medial side on the distal end of the tibia. It is something like the styloid process of the radius. The inferior surface of the tibia and the lateral surface of the malleolus articulates with the talus to make the ankle joint. You can feel the medial malleolus as the bump on the inside of the ankle (Figure 4-12).

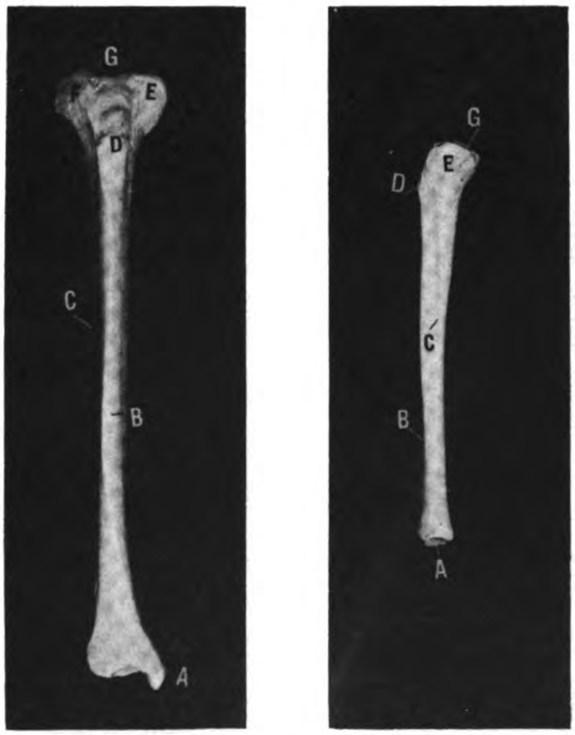



Figure 4-12 Tibia - AP and Lateral Views

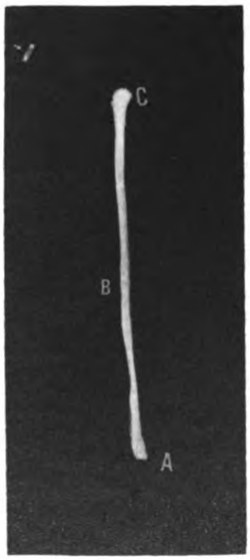
The anterior crest is the shin of your leg. You can feel it all the way up the front of your leg. The interosseous crest is on the medial side of the bone and corresponds to the interosseous crest of the radius.

The tibial tuberosity is the bump just below the knee joint on the anterior surface of the bone. One of the tendons of the thigh fastens itself to this structure.

The medial and lateral condyles are the two spread out areas on the proximal end of the bone. The superior surface or the top of these condyles are hollowed out slightly so that the thighbone fits into them to form the knee joint. Between these two condyles on the superior surface you will have bony projections that are called the intercondyloid eminences, (inter is between; between the condyles). These intercondyloid eminences keep your knee joint from slipping from side to side. On top of these condyles are little rings of cartilage that are called MENISCI. These menisci (men-i-ski) help to make the knee joint freely movable. If they are damaged the bones will rub against each other causing disablement. If they break loose and slip around it would be like sticking a rod through the back of a door. You wouldn't be able to close the door all the way and in the knee you couldn't bend it or straighten it out normally.

On the lateral side of the bone, both at the distal and proximal ends you will have smooth little areas called FACETS (H). Facets are the areas where one bone articulates with another. On the distal end of the tibia there is a facet for the fibula's lateral malleolus. On the proximal end will be a facet located on the lateral and inferior surface of the lateral condyle. This facet is for the head of the fibula.

<u>The Fibula.</u> The fibula is the lateral bone of the leg. It is a slender bone with the distal end somewhat pointed and the proximal end more rounded. Each end has an arrowhead shape. The structures of the fibula are the LATERAL MALLEOLUS (A), INTEROSSEOUS CREST (B), AND THE HEAD OF THE FIBULA (C) as shown in Figure 4-13.



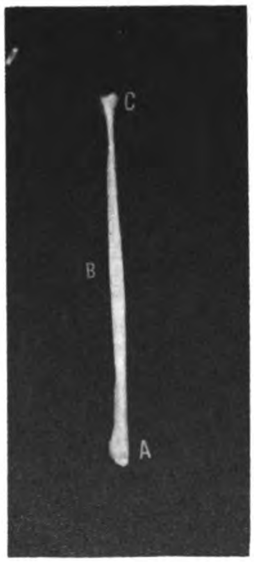




Figure 4-13 Fibula - AP and Lateral Views

The lateral malleolus is located on the distal end of the fibula. It can be felt and seen as the bump on the outside of the ankle. This lateral malleolus articulates with the facet provided for it on the tibia. The interosseous crest is on the medial side of the bone and corresponds to the interosseous crest of the ulna in the forearm. The head of the fibula is located on its proximal end. On the medial side of the head is a facet which articulates with the facet of the tibia. You can feel the head on the lateral side of the leg just below the knee joint. You can see it also.

The knee joint is made up of the condyles of the tibia and the lower end of the thighbone. The lateral bone or fibula does not enter into structures of the knee joint. The joint is filled anteriorly with the triangular-shaped patella. It is the largest sesamoid bone in the body. Sesamoid means "seed".

THIGH. The thighbone is the FEMUR. It is the largest, longest and strongest bone in the body. It has a shaft and two extremities. The distal extremity helps make up the knee joint. The structures on the femur are the MEDIAL (A) AND LATERAL (B) CONDYLES, INTERCONDYLOID FOSSA (C), POPLITEAL TRIANGLE (D), LINEA ASPERA (E), GREATER (F) AND LESSER (G) TROCHANTERS, INTERTROCHANTERIC CREST (H), FEMORAL NECK (I) AND THE HEAD OF THE FEMUR (J) as shown in Figure 4-14.

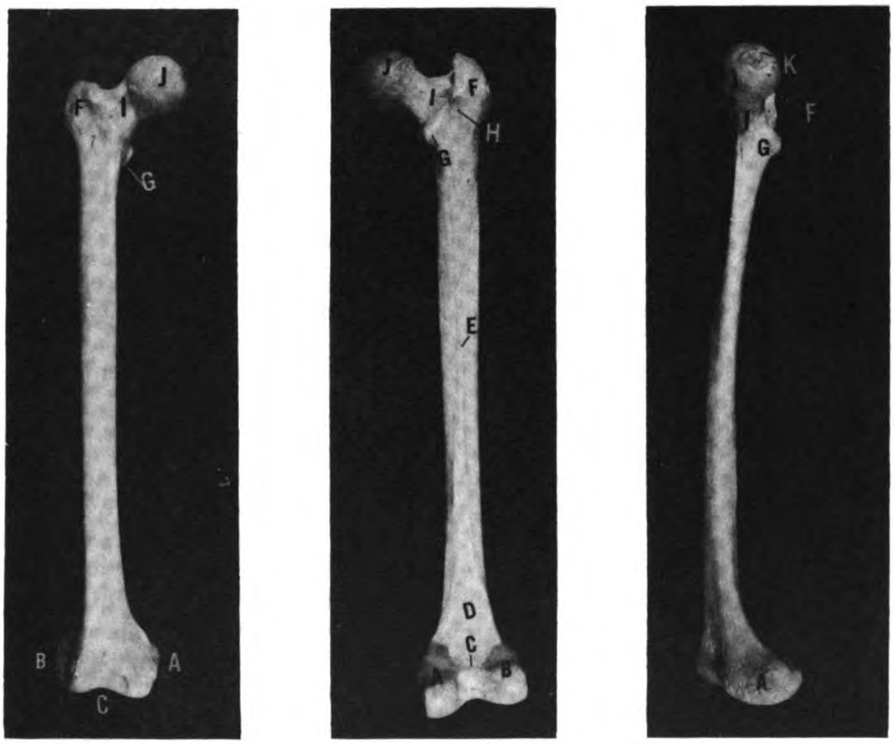



Figure 4-14 The Femur - AP, PA and Medial Side Views

The condyles are located on the distal end and articulate with the condyles of the tibia. The condyles of the femur are round-like knuckles whereas the condyles of the tibia are depressed on their superior surface so the femur can set into them.

The intercondyloid fossa is located on the distal end of the femur on the interior and posterior surfaces. The intercondyloid eminences of the tibia go into this fossa. This is also the location where some of the ligaments that bind the knee joint are fastened.

The popliteal triangle is on the distal end of the femur, too. It is also on the posterior surface just above the condyles and the intercondyloid fossa. It is a triangle area due to the ridges that spread from each condyle and join the ridge along the middle of the bone which is called the linea aspera. The linea aspera, then, is located on the posterior surface of the shaft. Its purpose is to provide a place to fasten muscles.

On the proximal end of the femur you will find the greater and lesser trochanters. The greater trochanter is located on the lateral side of the proximal end. The lesser trochanter is a smaller more rounded process that is located slightly below the greater trochanter, but on the medial posterior surface of the femur. Both of these trochanters are used for fastening muscles. Running from the greater trochanter, posteriorly and obliquely downward to the lesser trochanter, is a prominent rounded ridge that is called the intertrochanteric crest. You will be able to feel the greater trochanter if you place your finger on your hip and swing your leg back and forth. The hard area that you feel will be the greater trochanter. The lesser trochanter and the intertrochanteric crest are buried under heavy muscle so you cannot feel them.

Above the trochanters is the constricted "neck" or the femoral neck of the femur. It is directed upward, medialward and is turned slightly forward. It is important that you remember this. This angle at which the neck takes off from the shaft of the femur will be of importance to you later on. In males the angle is not so acute, but in the female it is greater.

Above the neck is the femoral head. The head is a round hemisphere and fits into the acetabulum of the hip bone. On the end of the head there is a small depression which is called the FOVEA CAPITIS (K). In an X-ray you will see it as a tiny gouged out area at the end of the head. This fovea capitis is an area where blood vessels enter the head of the femur.

The hip joint is a very important joint and is a frequent site of injury. Now in reviewing the lower extremity as a whole you will notice that whenever you rotate your foot or leg that the hip rotates with it. It is not like the forearm which can be rotated without much motion at the shoulder joint. Extend your leg and then rotate your foot in and out. The whole lower extremity will rotate from the hip joint. When you are lying down your foot will normally point laterally. Keep these points in mind when you come to your positioning chapter.

Now you should know all the bones of the lower extremity. You should know that there are fourteen phalanges, five metatarsals, seven tarsals, one tibia, one fibula and one femur. And you should know what these bones look like, what structures they have on them and where these are located. Generally the hip bone is included in the lower extremity, but this manual will place it in the pelvis structure.

You have now finished the upper and lower extremities. These two areas are known as the AXIAL SKELETON. They are appendages of the trunk of the body.

## THE TRUNK

This portion of the body is divided into three regions: the pelvic bones, the spinal column and the thoracic cage. The trunk is an important area to the radiology technician but the bulk of it is made up of soft tissue organs that you will encounter later.

THE PELVIS. The pelvis is made up of two innominate bones and the sacrum of the spinal column. The shape of the pelvis is different in the male and female. The male pelvis is smaller across than the female. The female pelvis is larger because of the need for space in childbearing.

The Innominate Bone. The innominate bone of the pelvis is actually made up of three different bones. These bones are the ILIUM (A), THE PUBIS (B) AND THE ISCHIUM (C). These bones ossify separately and then unite at the hip joint to form the ACETABULUM (D) in which the head of the femur sits (Figure 4-15).

The Ilium. The ilium is the large wing-like upper portion of the pelvis. This wide flaring portion of the pelvis is known as the GREATER PELVIS (E). The ilium has some very important structures that you must know. They are the ILIAC CREST (F), ANTERIOR SUPERIOR ILIAC SPINE (G), ANTERIOR INFERIOR ILIAC SPINE (H), POSTERIOR SUPERIOR ILIAC SPINE (I), POSTERIOR INFERIOR ILIAC SPINE (J), GREATER SCIATIC NOTCH (K), AND AURICULAR AREA (L).

The iliac crest is the top edge of the ilium. It is an important landmark to the X-ray technician. You can feel it throughout its entire length. Put your fingers into your waist. The bone of the pelvis that you are feeling is the ilium and the top edge you are feeling is the iliac crest.

Now if you follow the iliac crest toward the front it will end in a point. This point is the anterior superior iliac spine. As you see it is located on the anterior part of the ilium. Directly below it is the anterior inferior iliac spine.

On the anterior surface of the bone at the posterior edge is a rough oval area known as the auricular area. This area is a part of the sacro-iliac articulation or joint.

At the posterior edge of the iliac crest is the posterior superior iliac spine. You can feel this by placing your finger at the small of your back. It is in the area of the dimples caused by the sacro-iliac joint. And below it is the posterior inferior iliac spine. Below the posterior iliac spine is a cut-out area on the ilium that is known as the GREATER SCIATIC NOTCH.

The Ischium. The posterior projection of bone below the ilium is the ischium. On the superior portion of the ischium and posteriorly is a pointed process of bone that is known as the ISCHIAL SPINE (M). On an X-ray you will see it as it juts into the lesser pelvis from either side. Just below the ischial spine is another smaller cut out area which is known as the LESSER SCIATIC NOTCH (N). The branch of the ischium that is directed posteriorly just below the lesser sciatic notch is the ISCHIAL TUBEROSITY (O). You are sitting on your ischial tuberosities when you are seated. By placing your fingers at the transverse folds of the buttocks and pressing it slightly you will feel the ischial tuberosities toward the midline of the body.

Joining at the ischial tuberosity is the inferior "branch" or ramus of the ischium. This ramus forms the lower segment of the pelvis and is attached anteriorly to the pubic bone.

The Pubis. The anterior bone just below the ilium is the pubic bone. The pubic bone has three structures you should know. They are the SUPERIOR RAMUS (P), INFERIOR RAMUS (Q) AND THE SYMPHYSIS PUBIS (R).

The superior ramus extends from the ilium and runs across the body to the midline where its medial end makes up the symphysis pubis. The inferior ramus extends from the symphysis pubis posteriorly and laterally and meets with the ramus of the ischium.

The large hole that is formed by the ischium and pubic bones in the pelvis is known as the OBTURATOR FORAMEN (S). It is the largest foramen in the body. It is an important structure for the X-ray technician to remember.

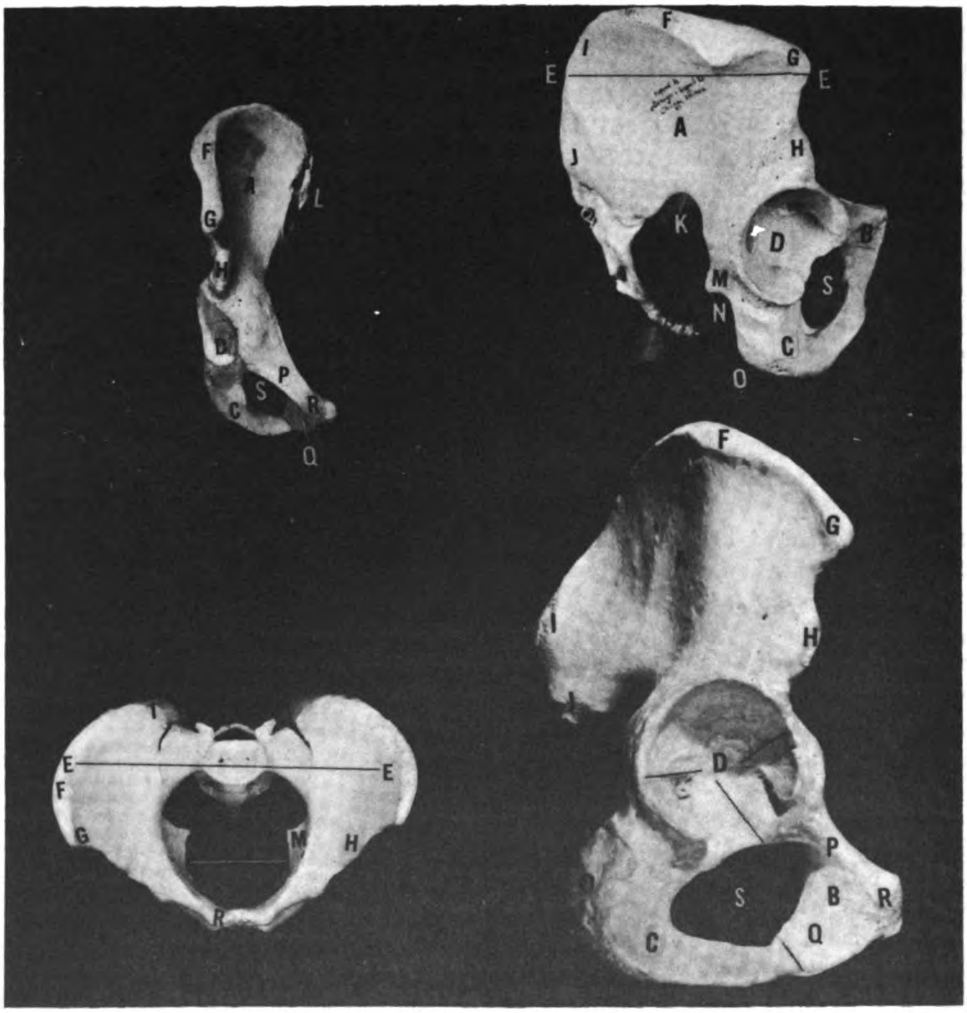


Figure 4-15 The Innominate Bone - AP, Lateral, Superior and Lateral Oblique Views

On the lateral side of the innominate bone, as has been mentioned before, is the place of union of the three bones of the innominate bone. This is the ACETABULUM. The acetabulum is a cup-like depression and is a part of the hip joint. Between the two pubic bones, which actually make up the symphysis pubis, is a space which is filled with a plug of cartilage. You can feel the symphysis pubis just above the beginning of the sex organs or under the pubic hair. It is also important as a landmark to the X-ray technician.

The lesser pelvis has been mentioned briefly, but it is the area at the bottom of the pelvis. It is the true pelvis. Pelvis means basin and you can see that the iliums form only a half of a basin where the ischium, the sacrum and the pubic bones form a more complete basin.

You should now have an idea of what the innominate bone consists of, how the pelvis looks, the structures that are in the pelvis and where these are located. You will go now to the vertebral column.

VERTEBRAL COLUMN. The vertebral column of the body is made up of thirty-three vertebrae. These vertebrae house the spinal cord of the body. The vertebral column is divided into five sections. Each section has a certain number of vertebrae. These sections are the CERVICAL VERTEBRAE, THORACIC VERTEBRAE, LUMBAR VERTEBRAE, THE SACRUM AND THE COCCYX. There are four very noticeable curves in the vertebral column that an X-ray technician must be aware of. The curves are two anterior or concave curves in the cervical and lumbar regions and the two posterior or convex curves that are in the thoracic and sacral regions.

Of the thirty-three vertebrae in the column only twenty-four can be considered freely movable. These are the vertebrae in the cervical, thoracic and lumbar regions. The vertebrae of the sacrum and coccyx are fused together and do not move separately (Figure 4-16).

A Typical Vertebra. A typical vertebra of the column will be described for you. There are a few vertebrae that differ in structures and these will be given to you individually.

A typical vertebra of the column will have a BODY (A), TWO PEDICLES (B), TWO LAMINAE (C), TWO TRANSVERSE PROCESSES (D), ONE SPINOUS PROCESS (E), TWO SUPERIOR ARTICULAR PROCESSES (F) AND TWO INFERIOR ARTICULAR PROCESSES (G). THERE WILL ALSO BE A SUPERIOR (H) AND INFERIOR VERTEBRAL NOTCH (I) ON EITHER SIDE. Between each vertebra will be an intervertebral disc (Figure 4-17).

The body will be located on the anterior part of the vertebra. On each side, in the back of the body, a stubby pedicle will jut out. These pedicles will join together with the two laminae, which are directed medially to meet on the midline, to form the vertebral arch. This arch houses the spinal cord. At the junction or union of the laminae and pedicles, the transverse processes jut out laterally. Also at the junction of the laminae and pedicles and transverse processes you will see the superior articular process. On the inferior side of the union of these three processes you will find the inferior articular process. The superior articular process has its facet facing posteriorly while the inferior has its facet facing anteriorly. This allows the vertebra on top to have a corresponding articular process on the bottom vertebra.

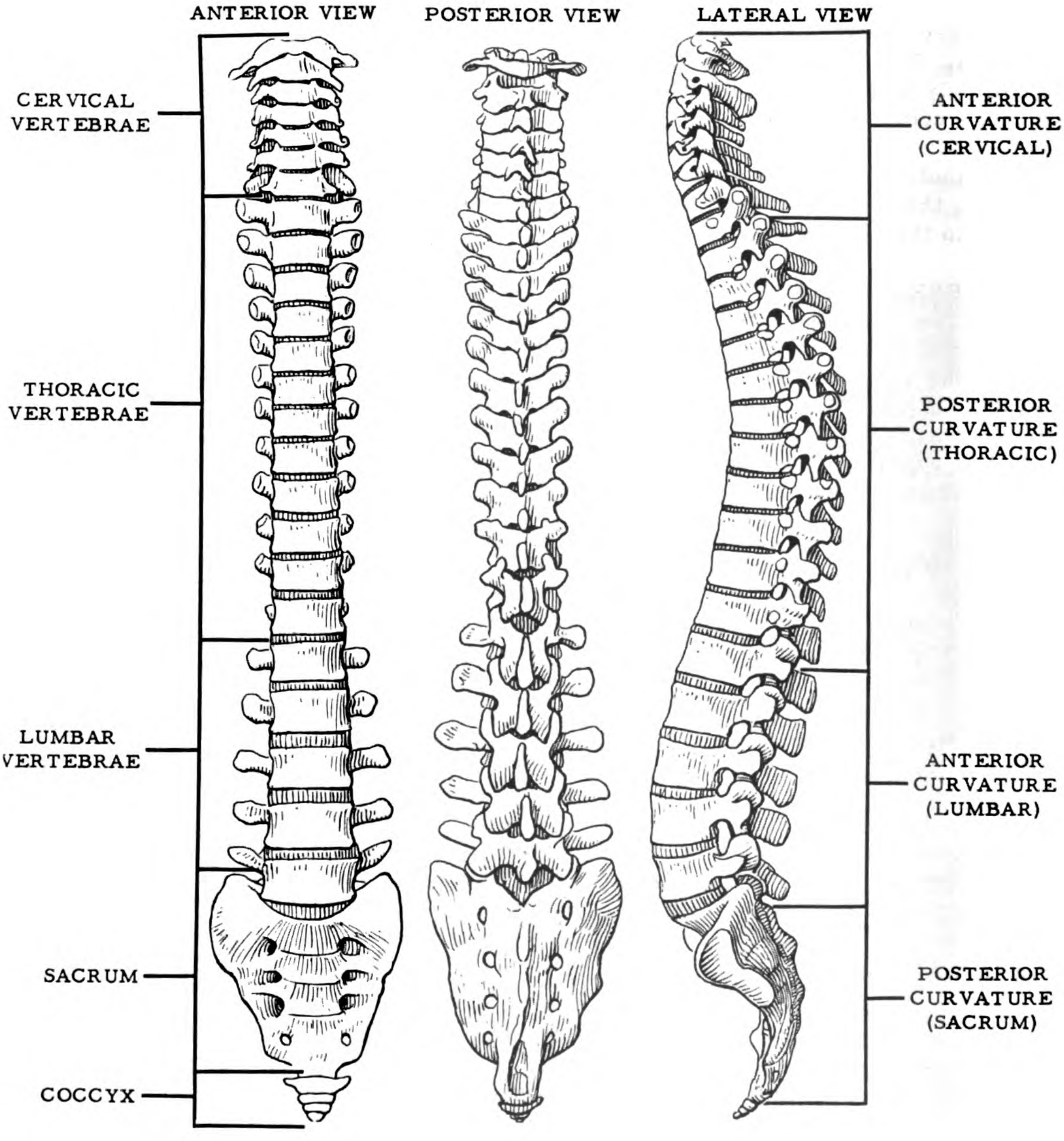



**Figure 4-16 Vertebral Column**

At the junction, in the midline, of the laminae there is a spinous process which is directed posteriorly or straight back.

This is the general description of the typical structures found on most vertebrae. You will now go through each region and see the various differences from this type of vertebra.

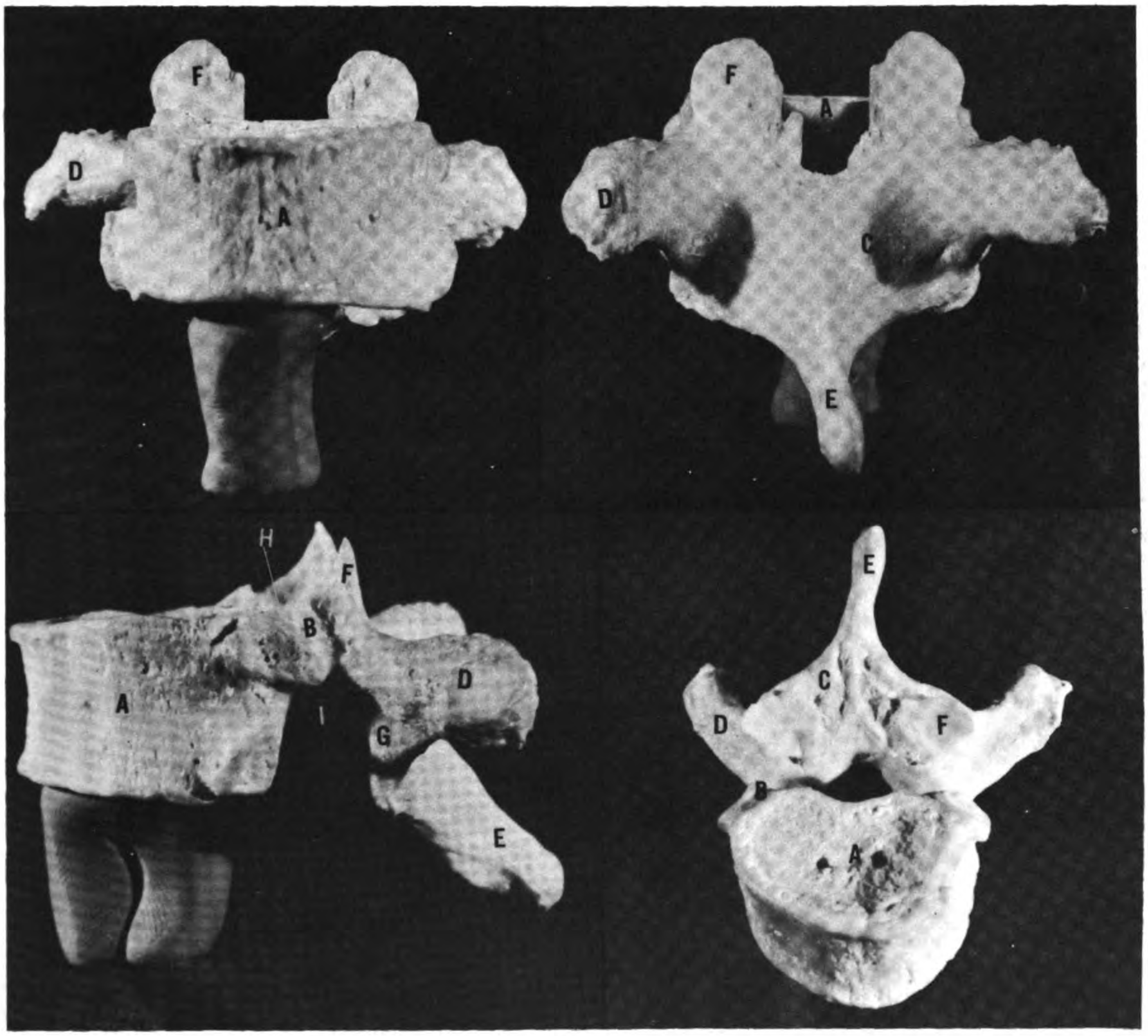



Figure 4-17 A Typical Vertebra - AP, PA, Lateral and Superior Views

The Cervical. There are seven cervical vertebrae. The first cervical is known as the ATLAS. It is different from typical vertebra. It is a ring of bone and has no body. The structures of the atlas are ANTERIOR TUBERCLE (A), POSTERIOR TUBERCLE (B), TRANSVERSE PROCESS (C), TRANSVERSE FORAMEN (D), LATERAL MASS (E), SUPERIOR (F) AND INFERIOR (G) ARTICULAR FACETS AND FACET FOR THE ODONTOID PROCESS (H). All these structures are located on the anterior half of the ring with the exception of the posterior tubercle. This tubercle is located on the midline of the posterior half of the ring on the outside surface (Figure 4-18).

The anterior tubercle is located on the anterior external surface of the ring. Just behind the anterior tubercle on the internal side of the ring is the facet for articulation of the odontoid process of the second cervical vertebra.

Sitting between the anterior and posterior halves of the ring are the lateral masses. On these masses you will find the transverse process jutting laterally from the mass. In this transverse process, close to the ring, is the transverse foramen. The cervical vertebrae are the only vertebrae that have foramen in their transverse processes. On the superior surface of the lateral masses you find the superior articular facets that articulate with the condyles of the skull. Directly beneath them on the inferior surface of the lateral masses will be the interior articular facets that articulate with the second cervical.

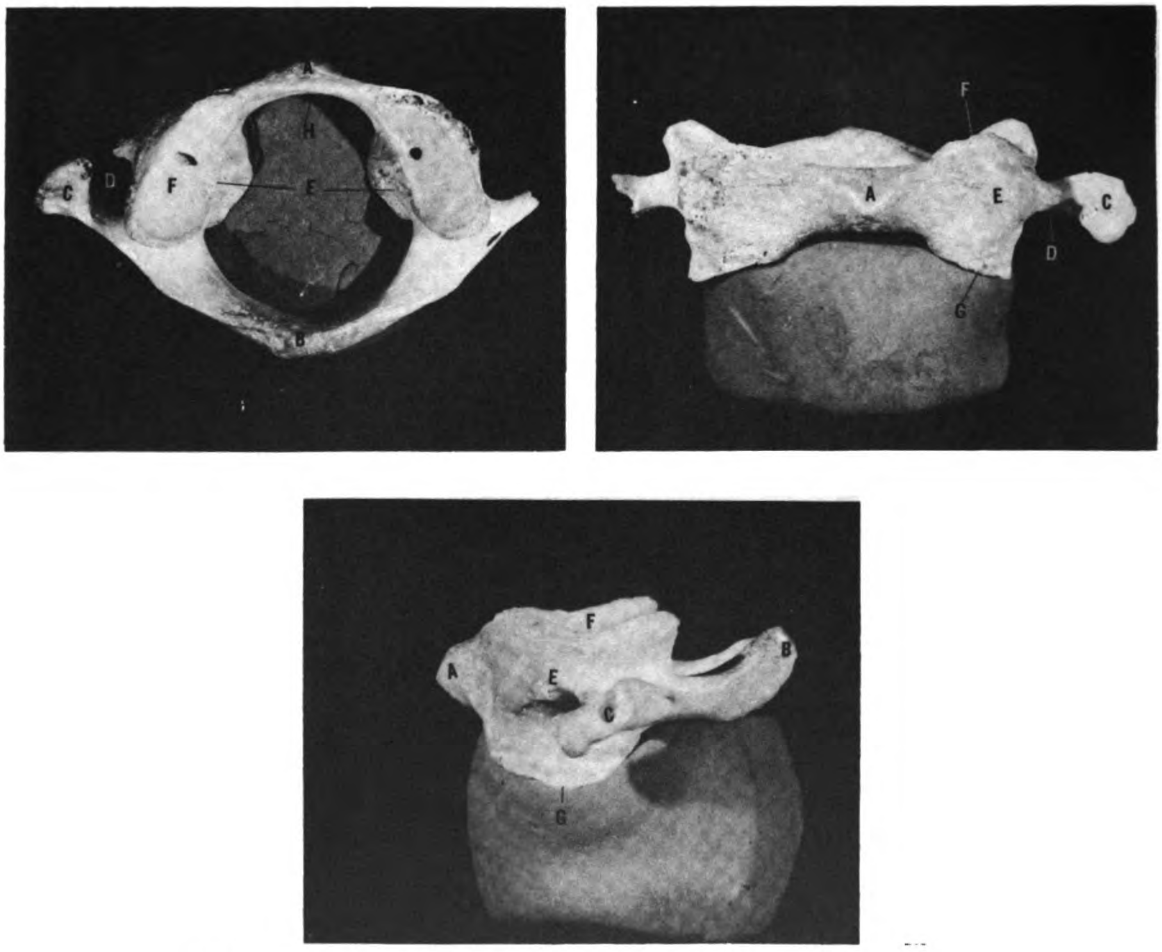



Figure 4-18 Atlas - Superior, AP and Lateral Views

The second cervical vertebra is known as the AXIS. It also varies from the typical vertebra. The axis has a few structures you should know. They are the ODONTOID PROCESS (DENS)(A) AND A BIFID SPINOUS PROCESS (B). The spinous process is wider and heavier on the axis than on any other cervical vertebra. It is split at the end into two prongs or is bifid. Only the cervicals have bifid spinous processes. The odontoid process is located over the body of the vertebra and projects up

onto the internal surface of the atlas. There it articulates with the facet on the internal side of the ring opposite the anterior tubercle. A ligament, the transverse ligament, runs behind the odontoid process holding it in place (Figure 4-19).

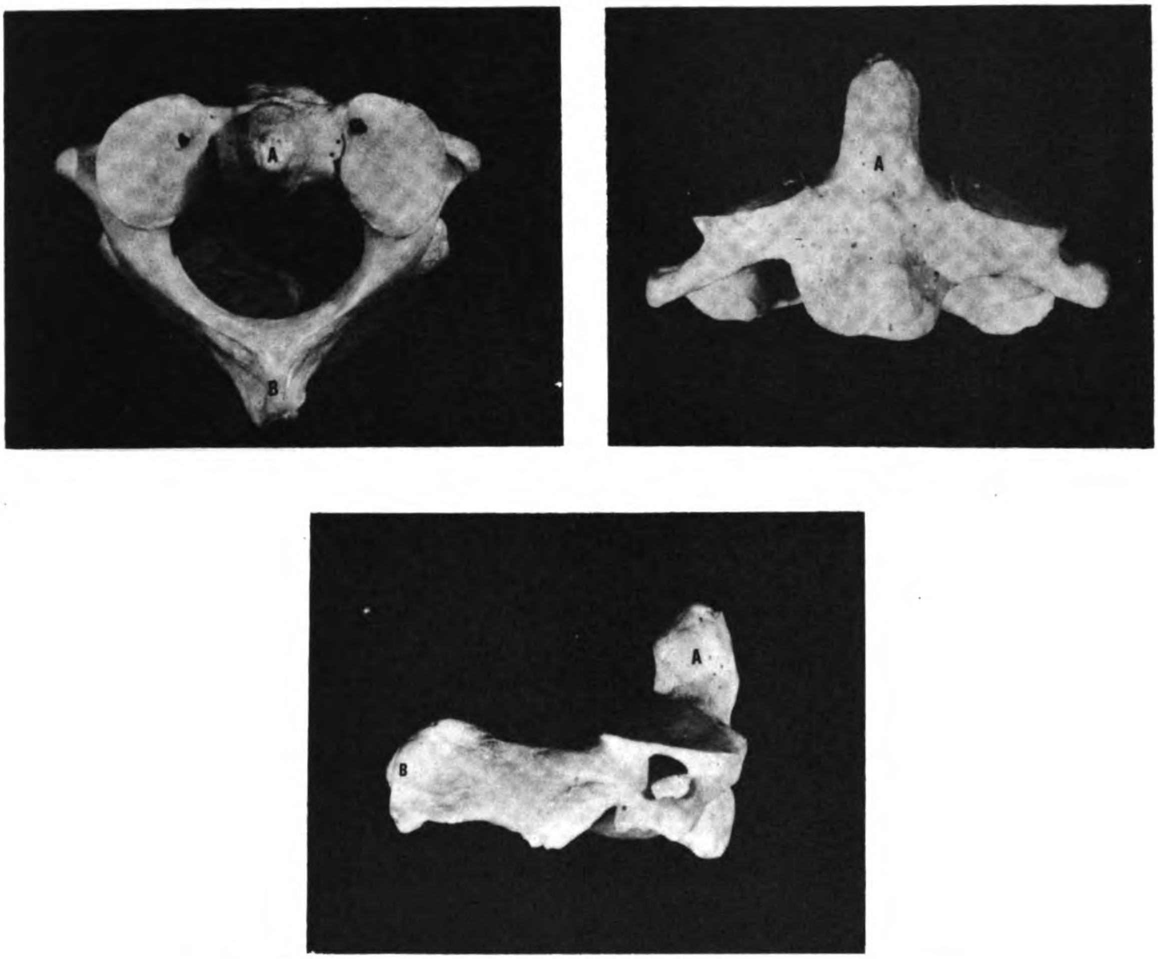



Figure 4-19 The Axis - Superior, AP and Lateral Views

The other cervicals, the third, fourth, fifth and sixth, are all about alike. They have foramina in the transverse processes and bifid spinous processes. The spinous processes are bent downward more than straight out like the other three. Also the body of the cervical vertebra has an overhanging lip on the bottom anterior edge that fits over a depression on the top of the vertebra below it. The seventh cervical vertebra is different because it has a longer spinous process that is not bifid or split. (Figure 4-20).

The Thoracic. There are twelve vertebrae in the thoracic spine. The thoracic spine continues from the cervicals. They have all the typical structures, as well as a few variations that you should recognize (Figure 4-21).

The top four thoracic vertebrae have some slight cervical features. The four middle vertebrae are "typical vertebrae" and, as you will see later, the last four have features of the lumbar area. Each of the thoracic vertebrae articulates with the

ribs. There are facets for these articulations on the bodies and the transverse processes. The first thoracic vertebra has a facet on the posterior lateral side of the body which is placed just below the superior surface of the body. On the inferior edge of the first is another facet which forms a half facet. The other half is on the vertebra below it. These facets are found down to the tenth thoracic vertebra. Only the tenth has a facet on the superior edge. Also the same thing is seen with eleven and twelve, but the facets are found on the pedicles and not on the body. The angle of the spinous process is only about 45 degrees in the first four. The angle in the middle four is greater in the downward direction and overlap each other somewhat. The last four spinous processes resemble the lumbar spinous processes by being wide and projecting back without such a great angle as the upper eight. You should notice also that the bodies of the middle four vertebrae are deeper in the posterior half and narrow or not as thick in the anterior half. The superior and inferior articular processes of the thoracic vertebrae are angled very little from a straight up and down line through them. This vertical position of the facets progresses as you come down the thoracic vertebrae. This is important for you to remember when you have to take a film of the articulations.

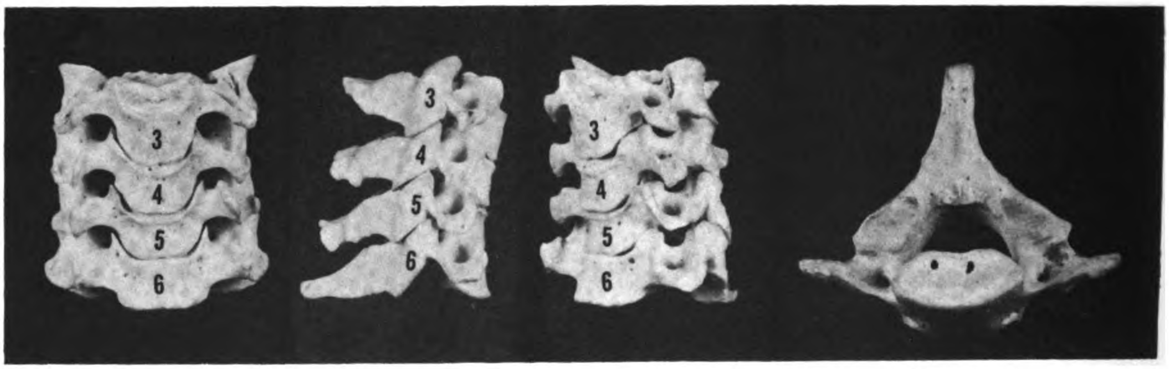



Figure 4-20 The Third, Fourth, Fifth, Sixth and Seventh Cervicals

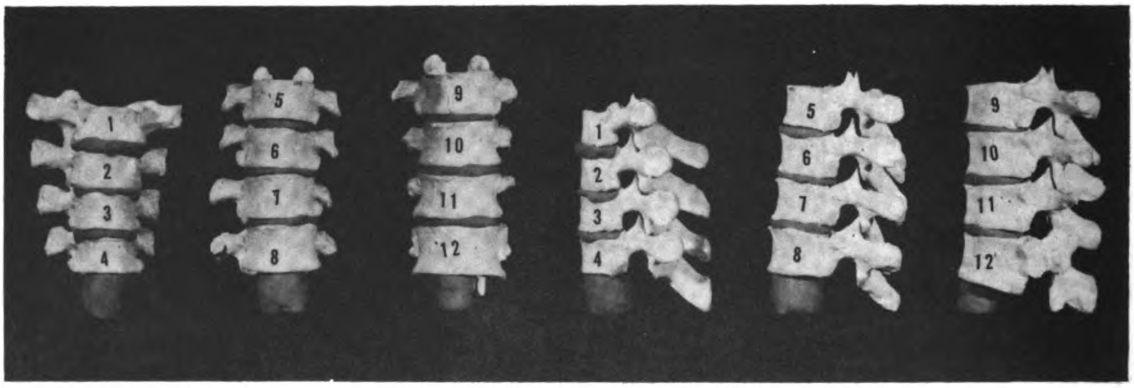



Figure 4-21 Thoracic Vertebrae - AP and Lateral Views

<u>The Lumbar</u>. There are five vertebrae in the lumbar region of the vertebral column. These vertebrae are larger for they bear a great deal of the weight of the body. They are different from the other vertebrae mainly because of their wide,

thick and short spinous processes. These processes stick straight back from the vertebrae so do not have the downward angle that is seen in the thoracic. The superior and inferior articular processes are almost vertical with the slight exception of the fifth. And opposite to the thoracic vertebrae, the bodies of the fourth and fifth lumbar vertebrae are thicker from top to bottom in the front and narrow from top to bottom in the back (Figure 4-22).

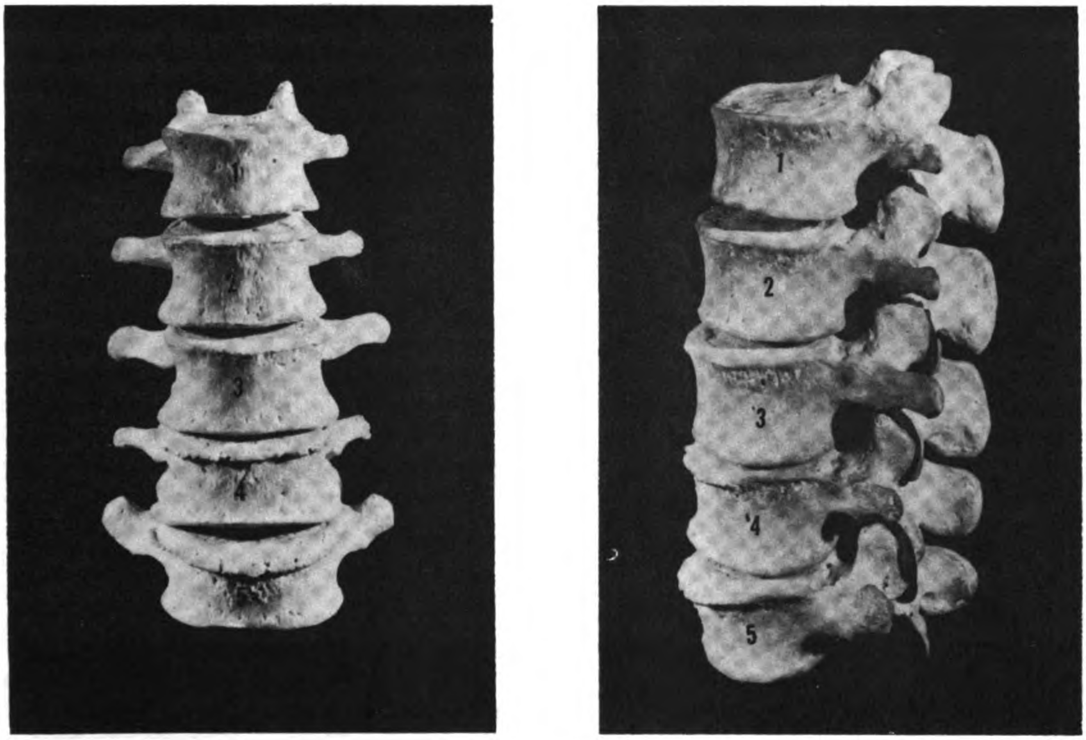



Figure 4-22 Lumbar Vertebrae - AP and Lateral Views

It is in the lumbar region that the spinal cord begins to terminate. The spinal cord ends at the level of the second lumbar vertebra into a structure of the cord which resembles the tail hairs of a horse. Because of this it is known as the CAUDA EQUINA (cauda means tail and equina means horse). It is also in the lumbar region below the cauda equina that "spinal punctures" are performed. You will see this method of putting parts of the body to sleep a great many times.

The fifth lumbar vertebra is important to the technician. It forms a part of the LUMBRO-SACRAL JOINT OR ARTICULATION. It is in the lumbar region that the "low back pain" originates quite frequently and you will be called upon a great many times to examine this region.

The Sacrum. The structures you should know on the sacrum are the BODY (A), SUPERIOR ARTICULAR PROCESS (B), ANTERIOR SACRAL FORAMINA (C), SPINOUS TUBERCLES (D), AURICULAR AREA (E), SACRAL CANAL (F) AND SACRAL HIATUS (G) as shown in Figure 4-23.

The sacrum contains five vertebrae. In the adult these vertebrae are fused

together and form one bone. This bone is triangular in shape with the apex or peak toward the feet. The base which is on the superior surface of the bone, articulates with the fifth lumbar and completes the lumbo-sacral articulation.


Figure 4-23 Sacrum - PA View

The body is more prominent at the top of the sacrum so that the body of the fifth lumbar can articulate with it. The sacrum, however, is angled back from the rest of the spine and is curved. The superior articular processes are on either side of the body on the superior surface of the bone. The facets face posteriorly to articulate with the inferior articular facets on the fifth lumbar. The anterior sacral foramina are the holes that you see on the front of the bone. There are four on either side. When you see the posterior surface of the bone they are the posterior foramina.

The spinous tubercles are on the posterior surface of the sacrum in the midline. They represent the spinous processes of the sacrum. On the superior, anterior and lateral edge of the sacrum is the auricular area. This is the roughened area on the sacrum which articulates on the auricular area of the ilium to complete the sacro-iliac joint or articulation. There is a plug of cartilage between the two bones so when this joint is examined there will be a space showing between them. The sacral canal is on the posterior surface of the sacrum in the midline. The spinous tubercles form the back part of the hollow canal and the body of the sacrum the front part. This canal spreads out about the bottom of the third segment of the sacrum into a triangular depression known as the sacral hiatus.

The Coccyx. The coccyx consists of four vertebrae. These also are fused together to some degree. They are the "tail end" of the vertebral column. The coccyx takes a slight curve that is opposite to the sacrum.

Location of Vertebrae. Now it is fine to know that there are thirty-three vertebrae, but the question always arises for the technician as to just where can he find these as individual vertebrae. It is sometimes necessary that you examine these vertebrae by themselves.

The cervical vertebrae are fairly easy to feel posteriorly. You can feel the spinous processes. The first and second cervicals can be located through the open mouth and they lie at the level of the angle of the jaw when the mouth is shut. The fourth cervical can usually be found directly under the "Adam's apple".

The hollow in the throat will provide you with a clue to the first and second thoracic vertebrae. You can also count down the ribs and follow them posteriorly through each thoracic vertebrae. The fourth, fifth and sixth thoracic vertebrae are on the level with the axilla or armpit where it folds when the arms hang down to the sides. In the average male you can use the nipples to locate these vertebrae. In the female this is not possible. The inferior angle of the scapula is in line with the seventh thoracic vertebra. And you can locate the ninth and tenth in the area of the xiphoid process of the sternum, which you will learn about soon.

The lumbar region will extend from the lower two ribs to a little below the iliac crest. The upper two lumbar vertebrae can usually be located by placing your fingers to the under edge of your lowest rib and drawing an imaginary line from the lateral side straight across to the vertebrae. The third lumbar you can find in the area of the belly-button or umbilicus on people of normal weight. You could not use this method on a fat person. At the level of the iliac crest you can find the fourth lumbar and one inch below the iliac crest you will find the fifth lumbar and the sacro-iliac joint. The sacrum you can feel. You can also find the center of it by finding the anterior superior iliac spine on the ilium and drawing an imaginary line across to the midline of the spine. The coccyx is found at the beginning of the crease of the buttocks. These locations will vary from person to person, but are generally accurate enough to locate vertebrae you want.

THORACIC CAGE. The thoracic cage is made up of the thoracic spine, the ribs and the sternum. There are only a few things that you must know about the bones in this area. The structures making up the thoracic spine have been discussed, so let's find out about the ribs.

The Ribs. YOU have twelve PAIRS OF RIBS. Women and men have the same number. The ribs have a shaft and two extremities. The first seven pairs of ribs are called TRUE RIBS. This is because they articulate with the vertebral column and the sternum. The last five are known as FALSE RIBS because they are connected by cartilage to the sternum. The last two ribs of the false ribs are known as FLOATING RIBS because they do not have a cartilage connection to the sternum.

Each rib has a vertebral extremity, which is posterior, and an anterior extremity. The posterior extremity has a head which articulates with the facets on the side of the body of the thoracic vertebrae. It also has a tubercle which articulates with the facet on the anterior and lateral side of the transverse processes of the thoracic vertebrae. The anterior end of the first seven are connected to the sternum by cartilage connections which join together and are directed upward to join the sternum. The last two have no anterior connection (See Figure 4-34).

The ribs slant downward in an oblique direction from the back to the front. This is important to remember because the anterior end is going to be lower than the posterior end. You cannot be certain of getting the right thoracic vertebra if you use the anterior end of a rib to locate it.

Now when you take in a breath notice that the ribs move up and outward. This does raise them a bit so that they are more horizontal. The X-ray technician needs to remember this little fact.

The Sternum. The sternum is the "breastbone". It is made up of three separate pieces. These pieces are the MANUBRIUM, THE BODY, AND THE XIPHOID PROCESS.

The manubrium is the superior part of the sternum. It has a notch on the top of it that forms that hollow at your throat. This notch is known as the manubrial notch or jugular notch. On either side of this notch on the lateral side there is an articular area for the sternal end of the clavicle. This joint is known as the sterno-clavicular articulation. Just below this joint is a facet for connection of the cartilage of the first rib. This facet is found on both sides.

The manubrium is connected to the body. At the union of the manubrium and the body is a facet for connection of the second rib. This connection between the manubrium and the body is known as the sternal angle. This is so called because the body angles back slightly so that there is a curve on the sternum. On the lateral side of the body there are other facets for the connection of the other true ribs.

On the inferior end of the body is a pointed piece called the xiphoid process. You can feel it in front just where the ribs come together. No ribs are connected to it.

You can see the ribs fairly well in many people. The sternum is superficial or right under the skin and can be felt. You can see the notch and feel the xiphoid.

This completes your study of the trunk of the body. The next section will take you into the study of the skull or cranium. Because it is a little more difficult to visualize you will have to study with care. Be sure to use the photos and the radiographs. The skull is an important structure to every technician.

## THE SKULL

The skull is not round as many people tend to believe. It is oval. In radiography you must be aware of the three various types of skulls which you are to encounter (Figure 4-24). These three types of skulls are:

- Brachycephalic Type - This head is broad from side to side, short from front to back and shallow from top to bottom.
- Dolichocephalic Type - This head is narrow from side to side, long from front to back and deep from top to bottom.
- Mesocephalic Type - This head is the average between the two above and is considered to be the most frequently encountered.

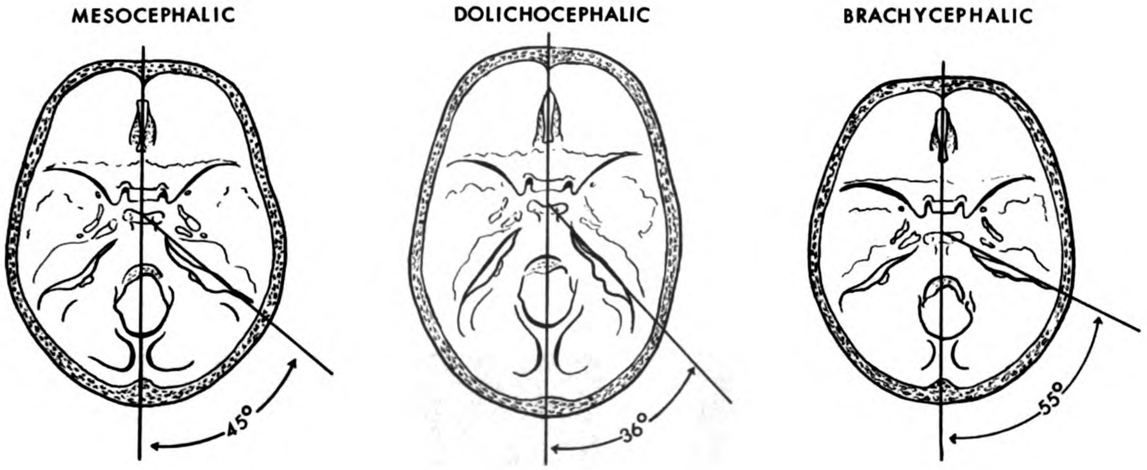



Figure 4-24 Skull Types

In the skull there are twenty-two bones. There are fourteen facial bones and eight cranial bones.

CRANIAL BONES. The eight bones of the cranium are the FRONTAL BONE (A), TWO PARIETAL BONES (B), THE OCCIPITAL BONE (C), TWO TEMPORAL BONES (D), THE SPHENOID BONE (E) AND THE ETHMOID BONE (F) as shown in Figure 4-25.

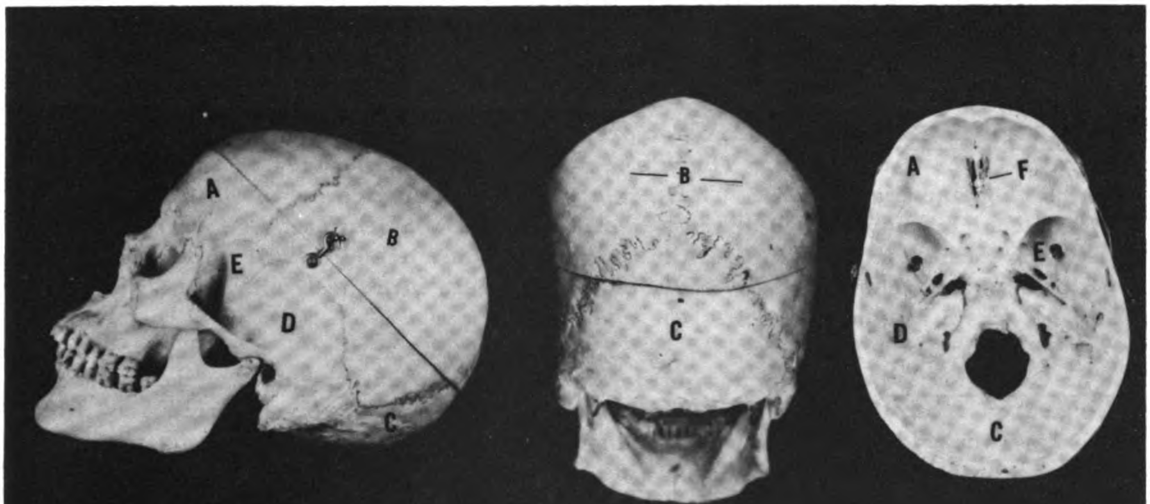



Figure 4-25 The Skull - Lateral, Posterior and Internal Base Views

The Frontal Bone. The frontal bone is the bone that lies under your forehead. It forms your forehead and the upper bone shelf of your eyes or orbits. Its structures are the ARCH (A), FRONTAL EMINENCES (B), SUPERCILIARY RIDGES (C), THE

FRONTAL SINUSES (D), AND THE SUPRA-ORBITAL FORAMEN (E) as shown in Figure 4-26.

The arch is that part which extends up to form the forehead. On this front plate on the outside of the bone are two slightly rounded prominences on the bone. These are the frontal eminences. They are just above the eyebrows. Right under the eyebrows you will feel a hard ridge. These are the superciliary ridges. In the center between the eyes and just above the root of the nose is an area that is known as the glabella. Directly behind this glabella area you will find the frontal sinuses. These sinuses will be described more fully later on.

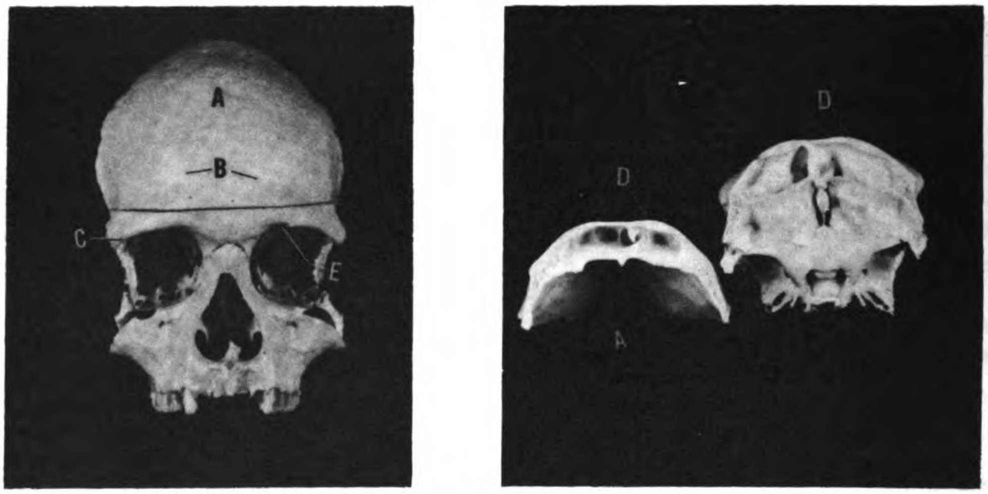



Figure 4-26 The Frontal Bone - AP View and Frontal Sinuses

The Parietal Bone. There are two parietal bones, one on each side of the head. They form the roof of the skull. There are no important structures on them that the radiology technician must know. There is a slight prominence on the lateral posterior surface that is known as the parietal eminence and sometimes there is a foramen near the suture line. If you will feel the top side of your head you will notice a slight bump which is parietal eminence. Both bones articulate with the frontal bone in front and with the occipital bone in back.

The Occipital Bone. The occipital bone is the bone at the back of your head. When separated from the skull it resembles a scoop with a narrow anterior neck for the handle and the wide flaring scoop making up the back of the head. It has a number of structures both on the inside and outside surfaces of the bone. Those structures on the outside or external surface are the SUPERIOR (A) AND INFERIOR (B) NUCHAL LINES, EXTERNAL OCCIPITAL PROTUBERANCE (C) AND THE OCCIPITAL CONDYLES (D). On the inside or internal surface are the FOSSAE FOR THE BRAIN (E), THE INTERNAL OCCIPITAL PROTUBERANCE (F), GROOVES FOR THE TRANSVERSE (1), SUPERIOR SAGITTAL (2) and OCCIPITAL SINUSES (3) (G) as shown in Figure 4-27.

The handle of the occipital bone is known as the BASILAR PORTION (H). The anterior edge articulates with the sphenoid bone. It has a groove on it for part of the brain stem that passes across it. Directly behind the basilar part of the occipital

bone is the largest foramen in the head. This foramen is the FORAMEN MAGNUM (I). Through this hole the spinal cord enters into the vertebral column.

The scoop of the occipital bone is called the SQUAMA (J). Squama refers to scale. A squama resembles the scales of a fish.

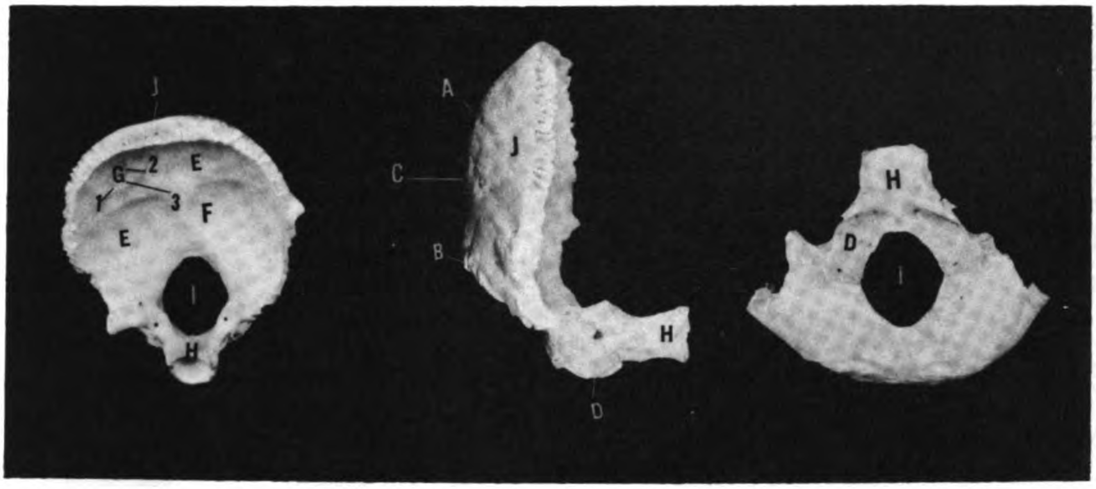



Figure 4-27 The Occipital Bone - Internal, Lateral and Inferior Views

The superior and inferior nuchal lines are ridges on the back lower part of the occipital squama. Between these lines and in the midline of the bone is the external occipital protuberance. You can feel this bump at the back of your head. These structures are used for the attachment of muscles which keep your head from falling onto your chest. The occipital condyles are on the inferior surface of the bone near the anterior edge of the foramen magnum. These condyles articulate with the superior articulating facets of the atlas, first cervical vertebra.

The fossae for the brain are divided into four areas by grooves of the transverse, superior sagittal and occipital sinuses. At the junction of these sinuses in the midline of the bone is the internal occipital protuberance.

The frontal, parietals and occipital bones are the simple bones of the skull. The more complicated bones of the skull are the temporals, the sphenoid and the ethmoid. They are not as easily visualized so care must be taken while you are studying them.

<u>The Temporal Bones.</u> There are two temporal bones. The temporal bones are under the area of the ear. They house the hearing organs and the structures that give you your sense of balance. The temporals have a number of different structures that you will be required to X-ray. These structures are found in five different areas. The areas are the mastoid (1), the petrous (2), squamous (3), tympanic (4), and styloid (5).

The squamous area is the flaring expanded upper portion of the temporal bone. It is thin and articulates with the parietal bone at the top and the sphenoid bone anteriorly. On the lower part of the squama is a projection known as the zygomatic pro-

cess (A) of the temporal bone. This process extends anteriorly and joins with the zygomatic bone to form the zygomatic arch. You can feel this arch on the side of your face as the cheekbone. Extending behind the zygomatic process posteriorly is the supramastoid crest (B). It runs up obliquely on the posterior part of the squama (Figure 4-28).

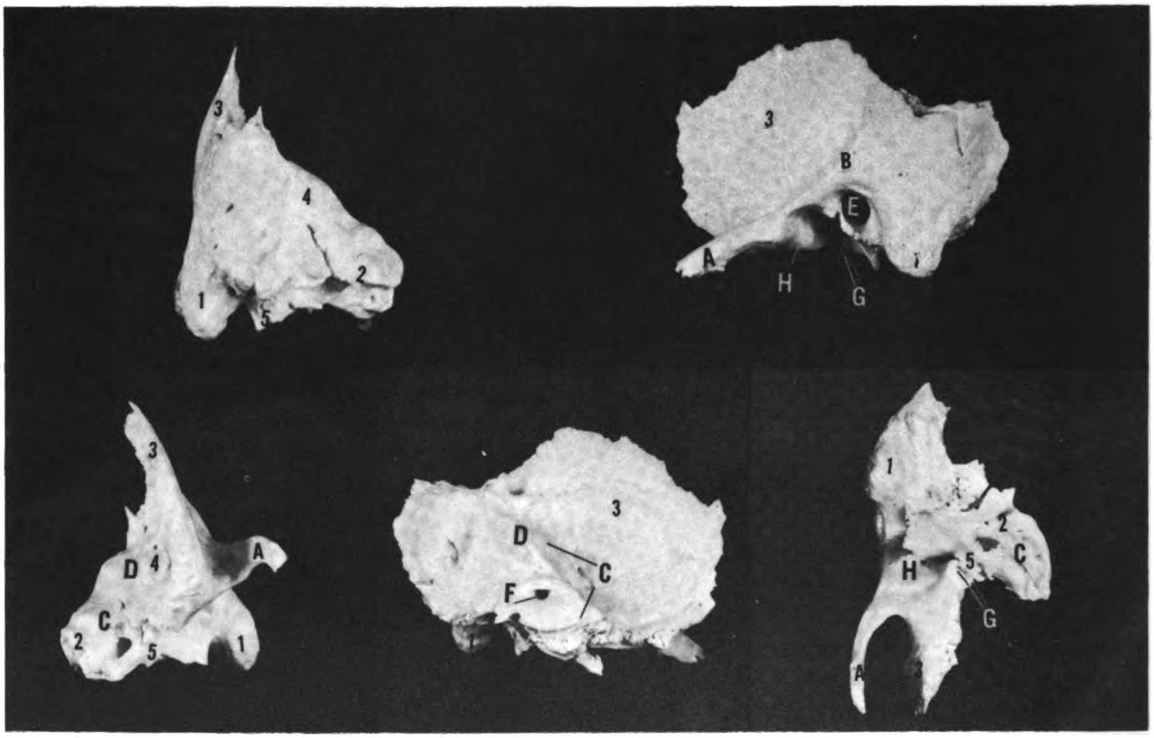


Figure 4-28 Parts of the Temporal Bone

The petrous area of the temporal bone is found on the inside of the skull. It is usually called the petrous pyramid or petrous ridge (C). It houses the hearing organs. This piece of the temporal bone is wedged into the base of the skull and runs anteriorly and toward the midline of the skull. It articulates with the occipital and sphenoid bones. The petrous pyramid is the densest bone in the skull. On a radiograph it will show as a white mass.

The tympanic portion (D) of the temporal bone is a curved part of the bone in front of the mastoid process. In this area you will find the hole of your ear. This hole is known as the EXTERNAL ACOUSTIC MEATUS (E). As this channel goes into the bone and into the petrous pyramid it becomes the INTERNAL ACOUSTIC MEATUS (F). As the channel broadens out to form the structures of the middle ear a small cavity is found that is known as the tympanic antrum.

The mastoid portion of the temporal bone is in the lower posterior part of the bone. You can feel it just behind your ear. It is a process that has numerous air cells in it. More air cells form as a person grows older so you may not see many cells in the X-ray of the mastoid of young children.

It is because of the air cells in the mastoids and the tympanic antrum that this area is so frequently radiographed. Infection in this area can get into these individual little cells and there is difficulty in getting it cleared up because of the many places in which the infectious organism may hibernate.

The styloid area is on the inferior surface of the temporal bone. The styloid process (G) of the temporal bone is found there. It is a spine of bone directed down and anteriorly. It is the place for attaching some of the muscles of the tongue. It lies just beneath the hole in your ear. The length of the styloid process will vary from person to person. Just anterior and lateral to the styloid process you will find a fossa for the insertion of the condyle of the mandible. This articulation is known as the TEMPOROMANDIBULAR ARTICULATION OR JOINT (H). Place your finger just anterior to your ear and then open and close your mouth. What you are feeling is the movement of the mandible condyle in the joint.

The Sphenoid Bone. The sphenoid bone of the cranium is a bat-shaped bone with two wings and a body. It is located anteriorly to the temporal bone and the basilar part of the occipital bone. It has a number of structures that you should know about. These structures are the GREATER (A) AND LESSER (B) WINGS, OPTIC FORAMEN (C), SELLA TURCICA (D), THE SPHENOID SINUS (E); LATERAL (F) AND MEDIAL (G) PTERYGOID PLATES AND THE HAMULUS (H). BESIDES THE OPTIC FORAMEN THERE ARE THREE OTHER FORAMINA ON THE SPHENOID BONE. These are the FORAMEN ROTUNDUM (I), FORAMEN OVALE (J) AND THE FORAMEN SPINOSUM (K). The sphenoid also forms, at the lateral posterior side of the body, a part of the FORAMEN LACERUM. All these foramina are used for passage of blood vessels and nerves (Figure 4-29).

The lesser wing of the sphenoid is on the upper anterior surface of the bone. As the wing joins the body of the sphenoid it sends out a process known as the ANTERIOR CLINOID PROCESS. Beneath this process lies the optic foramen. This foramen is directed anteriorly and laterally. It is used for passage of the optic nerve to the eyes. There are spaces between the lesser and greater wings that are known as the INFERIOR AND SUPERIOR ORBITAL FISSURES.

The greater wing of the sphenoid is inferior to the lesser wing, but sweeps up on the lateral sides until it is above the lesser. This part helps to form some of your temple area. The greater wing of the sphenoid houses all the foramina except the optic foramen.

Sitting between the wings is the body of the sphenoid bone. On top of the body is a structure known as the SELLA TURCICA. It is shaped like a saddle and is the location of the pituitary gland of the body. The front of the saddle is made up of the anterior clinoid processes. The back of the saddle has a piece coming up with two little processes on either side of it. This is called the DORSUM SELLA and the processes are the POSTERIOR CLINOID PROCESSES. The sella turcica and its structures are very important in many instances of disease. It will usually be found about one inch above the external acoustic meatus and one and one-half inches anterior to it.

Within the body itself is the sphenoid sinus. Below the body you will find the tail of the bat with the lateral and medial pterygoid plates. They flare out from just beneath the greater wing as it connects to the body of the sphenoid. The hamulus is the most medial section and extends below the plates somewhat.

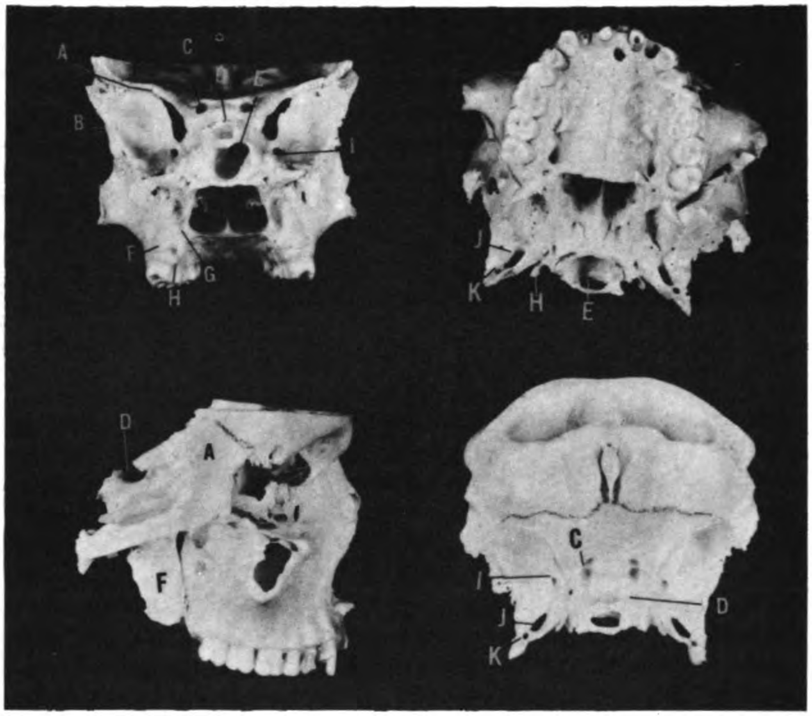



Figure 4-29 The Sphenoid Bone - PA, Inferior, Lateral and Superior Views

The Ethmoid Bone. Filling in the anterior middle floor of the skull is the ethmoid bone. It articulates posteriorly with the sphenoid. It is located right behind the nose and at the bottom of the frontal bone. It has a CRIBRIFORM PLATE (A), PERPENDICULAR PLATE, CRISTA GALLI (C), ANTERIOR (D) AND POSTERIOR (E) ETHMOID SINUSES AND A SUPERIOR AND MIDDLE CONCHAE (Figure 4-30).

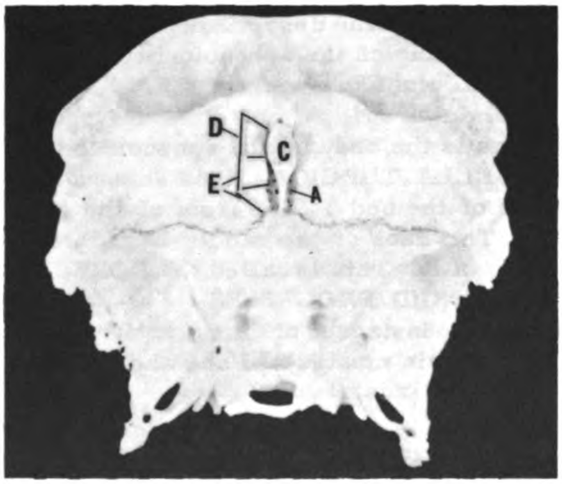



Figure 4-30 Ethmoid Bone - Superior View

The cribriform plate has many foramina on it for the olfactory or smelling nerve fibers. On the anterior superior surface is the crista galli which is shaped like the triangular sail on sailboats. On the inferior surface you will find a thin plate which is the perpendicular plate of the ethmoid. It helps to make up the superior and posterior part of the nasal septum. (A septum is a dividing wall of tissue, bone or cartilage). The ethmoid sinuses are found on either side of the cribriform plate. The bone helps make up some of the walls of the orbit, too. Beneath the plate the superior and middle conchae curl down like potato chips.

Cranial Sutures. As you know already the articulations of the skull are immovable and are of the synarthrosis type of joint. These articulations are called sutures in the skull. The suture between the frontal and the parietal bones is known as the CORONAL SUTURE (A). The suture that extends down the middle of the head between the parietal bones is the MID-SAGITTAL SUTURE (B). The point where the mid-sagittal and coronal sutures meet is known as the BREGMA (C). The suture dividing the parietals from the occipital bone is called the LAMDOIDAL SUTURE (D). The point where the mid-sagittal suture and the lamdoidal suture meet is known as the LAMBDA (E) as shown in Figure 4-31.

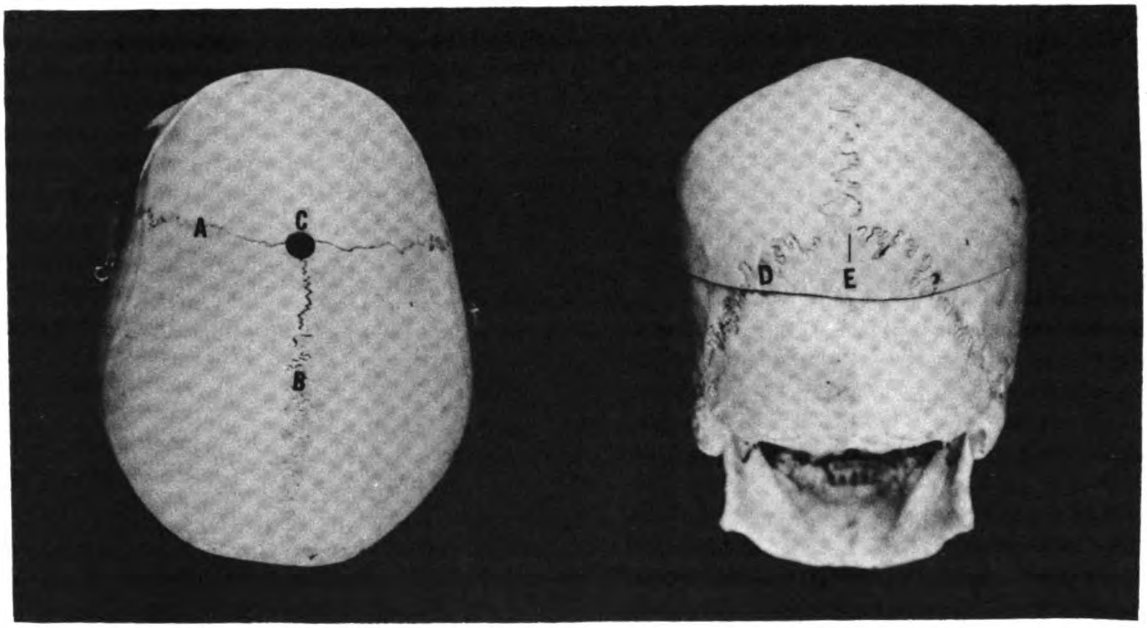



Figure 4-31 Cranial Sutures

In young infants these sutures are not closed and there are spaces filled with membranes connecting the more solidly formed bone. These are called FONTANELS. Notice on the next small baby you see how depressed the top of the head is where the frontal and the parietals meet. You might also see the pulsation of the spot due to the blood vessels beneath it.

You have now learned about the frontal, parietals, occipital, temporals, sphenoid and ethmoid bones of the skull or cranium. These as you now know form the brain box. In the box you will notice three levels. The high or anterior level is made up of the frontal bone which includes the superior part of the orbits, the ethmoid bone,

and the lesser wing of the sphenoid. The middle level is formed by the greater wing and the sella turcica of the sphenoid with some help from the petrous pyramid of the temporal bone. The posterior or lower level is formed by the occipital bone. The base of the skull is formed by the occipital, body of the sphenoid and its wing, and the ethmoid. The sides of the skull are formed by the temporal bones in connection with the lateral sides of the occipital bone and the lateral part of the sphenoid (greater wing). The top of the skull is formed with the squama of the frontal bone and the two parietal bones. Now you will continue with the facial bones.

**FACIAL BONES.** There are fourteen bones in the face. These bones are the NASAL BONES (A), LACRIMAL BONES (B), THE VOMER (C), INFERIOR NASAL CONCHAE (D), ZYGOMATIC BONES (E), PALATINE BONES, THE MAXILLAE (F), AND THE MANDIBLE (G).

There are two nasal bones. These bones are separated by a suture running between them and they articulate with the frontal bone. Just below the nasal bones and set in where the internal corner of your eye is, you will find two lacrimal bones. They are small and help form part of the medial wall of the orbit. The two zygomatic bones are found at the point of the cheek. They form the lateral side of the orbit. If you will take your finger and feel the outer corner of your eye you will feel the zygomatic bone. It has a slight projection posteriorly so that it meets the zygomatic process of the temporal bone to complete the zygomatic arch.

The maxillae are the two bones of the upper jaw. They house the maxillary sinuses. On the lower edge, where the teeth are inserted, is the AVEOLAR PROCESS. At the superior edge, just below the orbit is a foramen. This foramen is the INFRA-ORBITAL FORAMEN. The maxillae help make up the bottom floor of the orbit and the lateral wall of the nasal cavity (Figure 4-32).

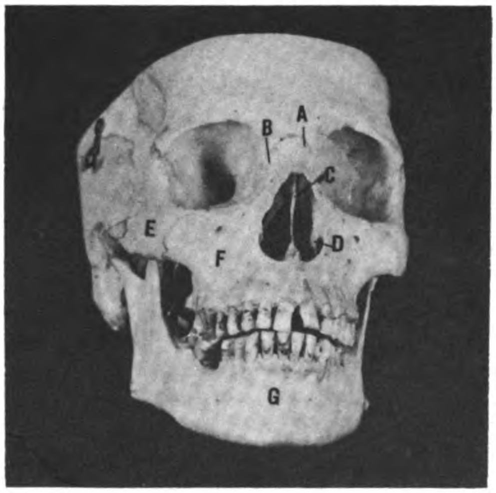



Figure 4-32 Facial Bones

The vomer bone is a thin plate of bone which completes the nasal septum. The vomer bone forms the lower part, and the perpendicular plate of the ethmoid forms the upper portion. It lies in the midline of the nasal cavity.

The palatines are two bones found at the back of the nasal cavity. These bones help form the roof of the mouth. They are sandwiched between the pterygoid processes of the sphenoid and the maxillae.

The inferior nasal conchae are two potato chip type of bones that come from the lateral wall of the nasal cavity.

The biggest bone of the face is the mandible. It is the lower jaw. It has a body (A) and two rami (B). The mandible, just as the maxilla, has an aveolar process. The mandible is sometimes separated in the midline by a suture, but generally this is not open for long after birth. It is known as the MANDIBULAR SYMPHYSIS (C). On either side of the body is a foramen. This foramen is the MENTAL FORAMEN (D). This foramen is an outlet for a canal known as the MANDIBULAR CANAL (E). On X-rays this canal can be seen as a dark line running along the body (Figure 4-33).

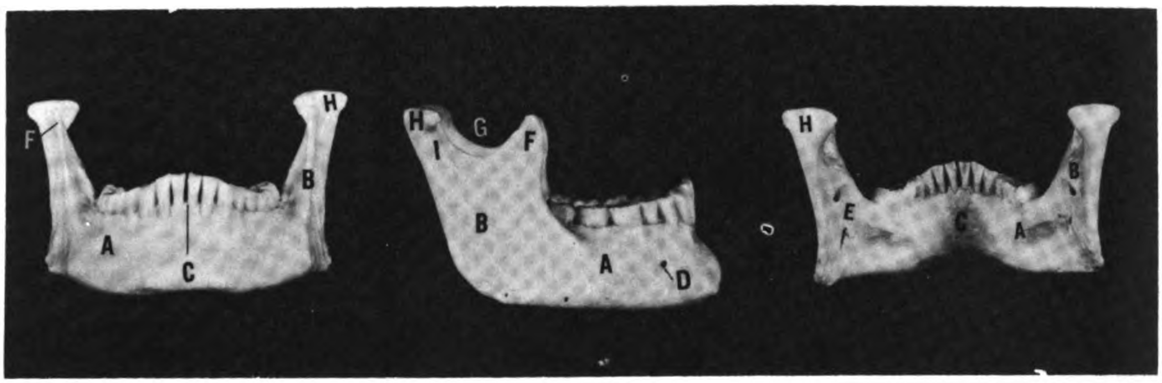



Figure 4-33 Mandible - AP, Lateral and PA Views

The ramus of the mandible extends up vertically from the body. At the top edge you will see two projections with a notch separating them. The anterior projection is the coronoid process (F) of the mandible. The notch is the mandibular notch (G). The rounded process that is posterior to the notch is the condyle (H) of the mandible. This condyle fits into the mandibular fossa of the temporal bone to form the temporomandibular joint. Below the condyle is a constricted area that is the neck (I).

You have now completed the study of the individual bones in the body. You have learned a number of different structures which you will use in identifying positions. You will be required to have more knowledge of the bones in this work, but they are only one part of the overall structure of the body. The skeleton is a dynamic piece of engineering. The relationship of each of its parts is the ultimate in leverage and support design. Knowledge of the skeletal system is an important beam in your framework of anatomical knowledge. Look at it in completion so that you can visualize its entire construction. Notice the relation of each structure to the other (Figure 4-34).

The physiology and structure of the other systems of the body must be known to the X-ray student. He will find that special examinations will reveal their outlines and functions so that he must be aware of the structures and actions of the circulatory, urinary, digestive, central nervous system, respiratory and reproductive systems. You will learn the structures of these systems, how each organ is related to the others and the ways in which these organs contribute to the entire system.

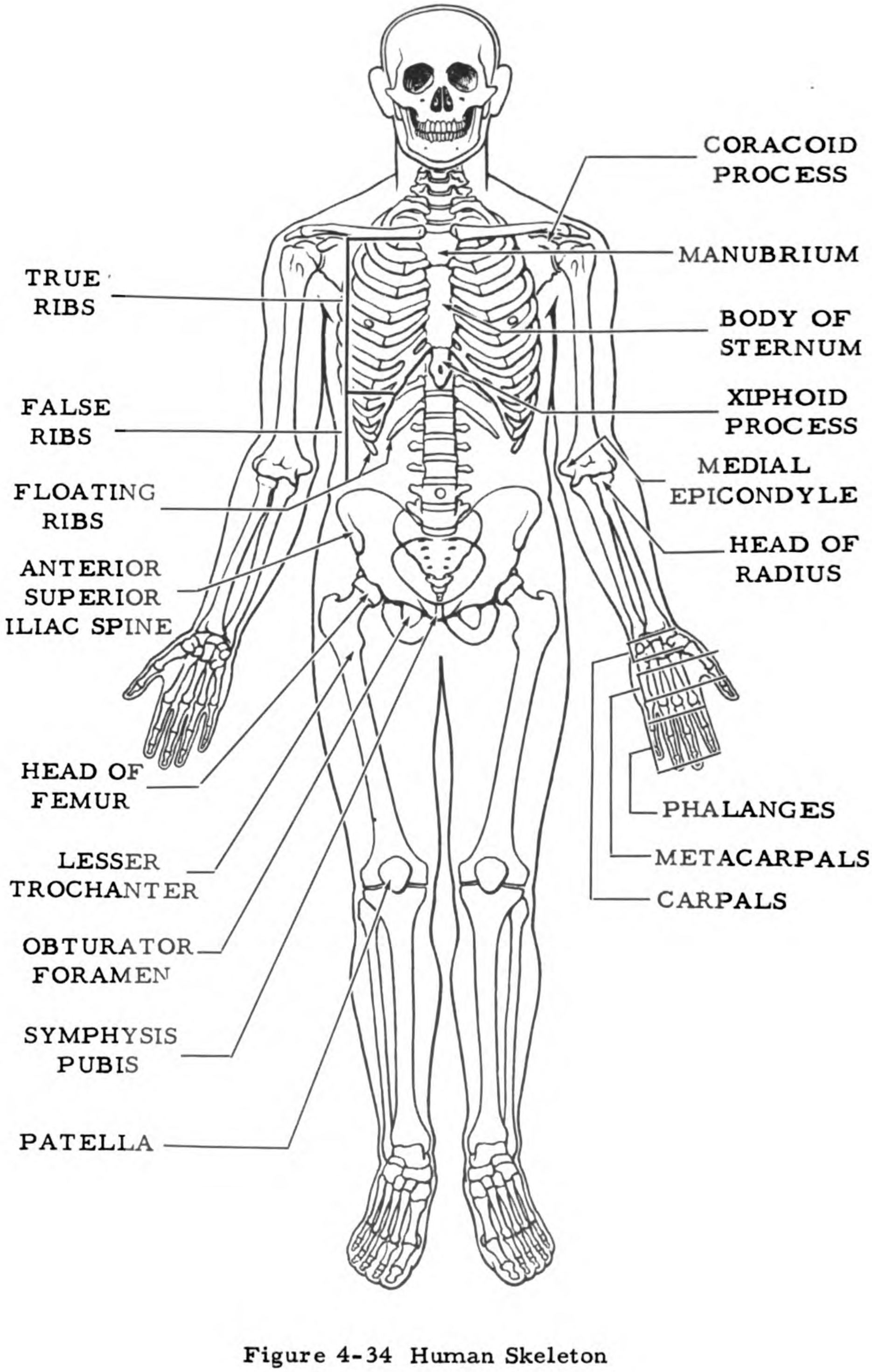



Figure 4-34 Human Skeleton

# CIRCULATORY SYSTEM

The blood vessel system is a closed circulation of the blood in vessels which begin at the heart and extend to the arteries, the capillaries, and the veins. This closed system of tubes, called blood vessels, circulates the vital oxygen-carrying blood to all parts of the body. The heart is the muscular pump which propels the blood through the vessels.

## THE HEART

The heart is a hollow muscular organ in the anterior part of the chest behind the sternum. It extends from about the second rib interspace to the level of the fifth space. It is about the size of the closed fist and resembles a strawberry in shape. The base of the heart is directed upward toward the neck and the apex is pointed downward, laterally and forward. More than two-thirds of the heart is to the left of the midline of the body.

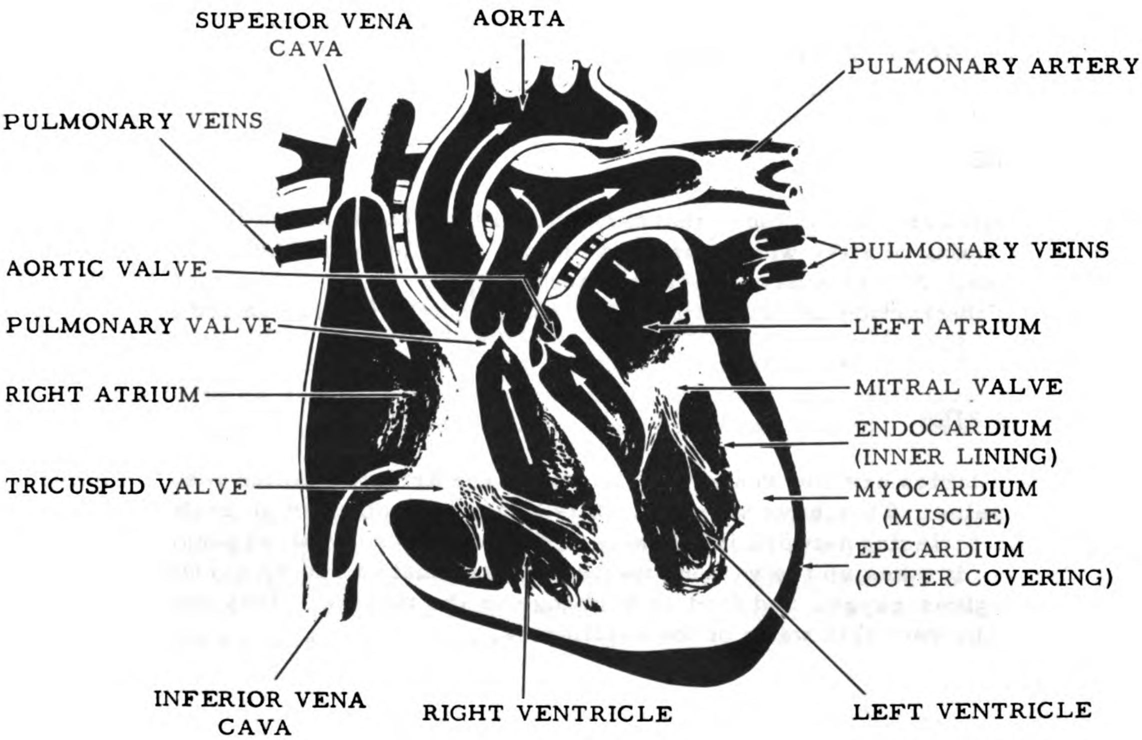



**Figure 4-35 The Heart**

Inside, the heart is divided into chambers. There are two atria and two ventricles. The heart has two sides, the right and left sides with an atrium and ventricle for each side. The wall of the left ventricle is thicker than that of the right because it does more work.

Between each atrium and ventricle are the valves which control the blood into each chamber. The tricuspid valve is between the right atrium and right ventricle. The pulmonary or semilunar allows the passage of the blood from the right ventricle to the pulmonary arteries. On the left side of the heart, between the atrium and ventricle, is the bicuspid valve. And from the left ventricle to the aorta is the aortic valve. The aorta is the main vessel that carries blood away from the heart.

The heart muscle contracts with a wringing motion that squeezes the blood into the vessels. It begins in the atria and passes through to the ventricles. The normal heart rate is about 72 beats per minute. This will vary according to sex, weight, exercise and temperature, however. The contraction of the heart is called the systole and is the period of work; the period of rest or relaxation is the diastole. Blood pressure is the force your heart exerts to push the blood through the arteries. The highest pressure is called the systolic blood pressure because of the contraction of the heart. Some blood pressure is present all the time even during relaxation of the heart. This is the diastolic pressure.

The normal blood pressure for a young adult is: Systolic, 120 mm. of mercury; diastolic, 70 to 90 mm. of mercury.

## THE ARTERIES

The arteries are elastic tubes that carry blood from the heart to the body. They have an inner lining of silky white tissue, a middle muscle layer and an outer layer of elastic tissue. Arteries have their own nerve supply, so they can vary their diameter during contraction or relaxation. The smaller arteries are called arterioles.

## THE CAPILLARIES

The capillaries are tiny vessels at the end of the arteries, which feed the blood back into the veins. They have very thin walls and communicate with each other and form a dense interlacing network in all parts of the body. As the blood passes through the capillaries, it takes up the various waste products that are to be carried away in the veins and gives oxygen and food in exchange to the tissues. This change takes place through the very thin walls of the capillaries.

## THE VEINS

Veins are hollow elastic tubes that carry the blood back to the heart. They are like the arteries but have thinner walls and not as much muscle tissue. They have valves which prevent the backflow of blood. The smaller veins are known as venules. These venules are formed from capillaries which have joined together to from a tiny stream.

## THE PATH OF CIRCULATION

Where does the blood flow in your body? Let's begin with the venous blood as it enters the heart. The right side of the heart is the venous blood side. The venous blood returns from the body and enters the right atrium which is the receiving chamber. It passes through the tricuspid valve into the right ventricle. As the right ventricle contracts the blood is forced through the pulmonary valve into the pulmonary arteries. These arteries carry the blood to the lungs where the waste is exchanged for new oxygen. The pulmonary artery branches off into an artery for each lung. As the blood passes around the lung it returns to the left side of the heart through four pulmonary veins which empty into the left atrium. This circulation is known as pulmonary circulation. The blood is dark when it enters the right side of the heart and bright red from new oxygen as it leaves the left side. This circulation through the lungs takes only about ten seconds.

After the blood is in the left atrium it enters through the bicuspid valve into the left ventricle. When the left ventricle contracts blood is forced out in the aorta through the aortic valve. The blood then goes to all the various arteries, arterioles, capillaries, venules and veins. Finally it enters the large veins that empty into the right side of the heart again. From the lower part of the body the venous blood enters the heart from the inferior vena cava. From the upper extremities, head and neck, it enters through the superior vena cava (Figure 4-35).

It takes under thirty seconds for blood leaving the heart to return after making a complete circuit of the body. In twenty-four hours your heart will receive and pump out 10,000 quarts of blood.

## THE BLOOD VESSELS

The system of arteries and arterioles is similar to that of a tree, with the aorta as a trunk, the arteries as large branches, and arterioles as small twigs. The blood circulates from the aorta to the arteries and then the small arterioles. In some cases the small arterioles unite in what is known as an anastomosis. Place your hands together so that your fingers slip in between each other and you can illustrate anastomosis.

The aorta is the large tubelike structure which arises from the left ventricle of the heart and arches upward around the left lung and then down and backwards along the front of the spinal column through the diaphragm. Along the way it gives off arteries to the head, neck, arms, chest, and abdomen, before finally dividing to send arteries down both lower extremities.

The aorta also sends small branches, called coronary arteries, to the right and left side of the heart, to nourish the heart muscles.

You should become familiar with the more important vessels. Three large arteries arise from the top of the aorta as it arches over the left lung. The first of these branches is the innominate artery, which divides into the right subclavian artery, to supply the right arm with blood, and the right common carotid, to supply the right side of the head (Figure 4-36).

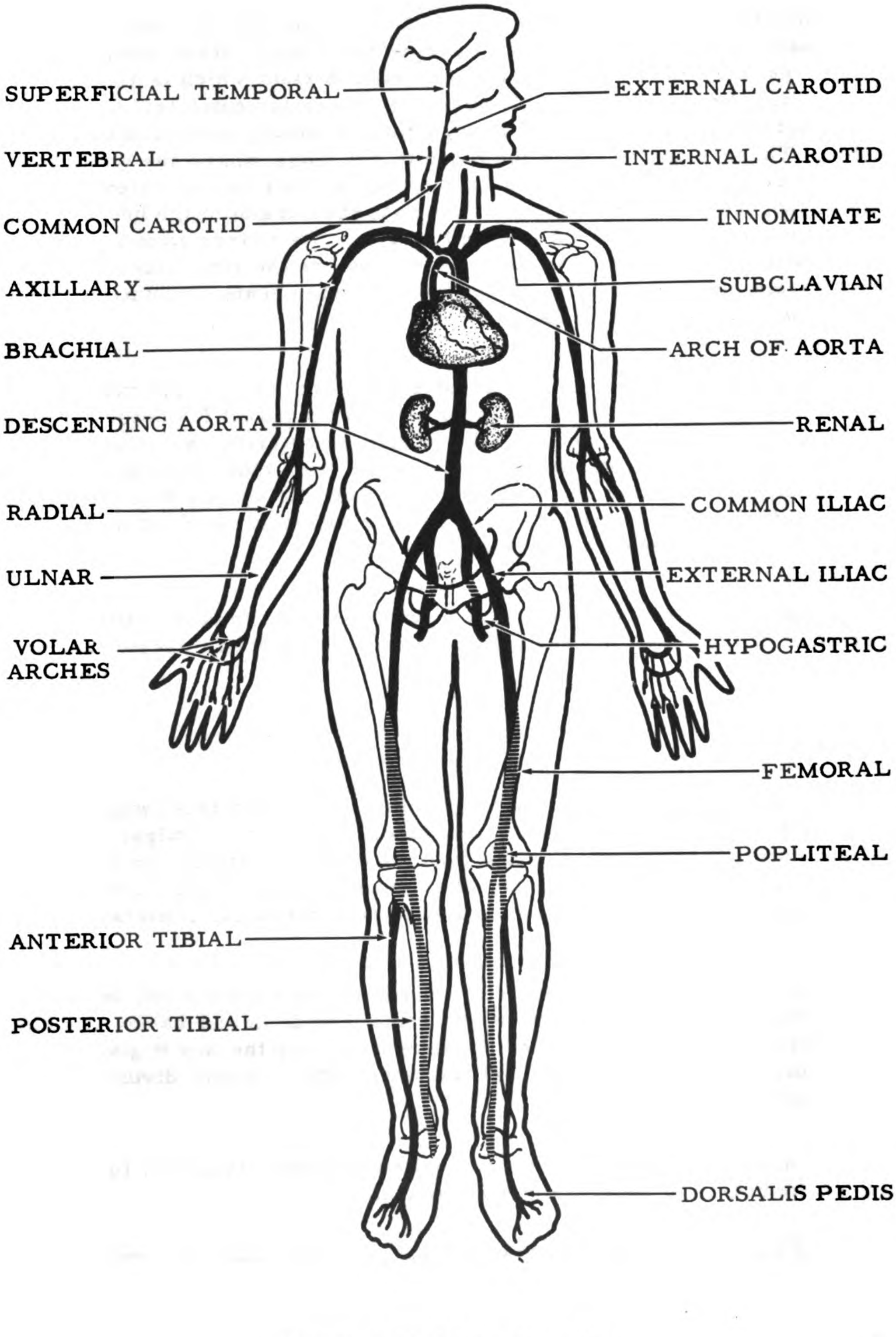



**Figure 4-36 Major Arteries**

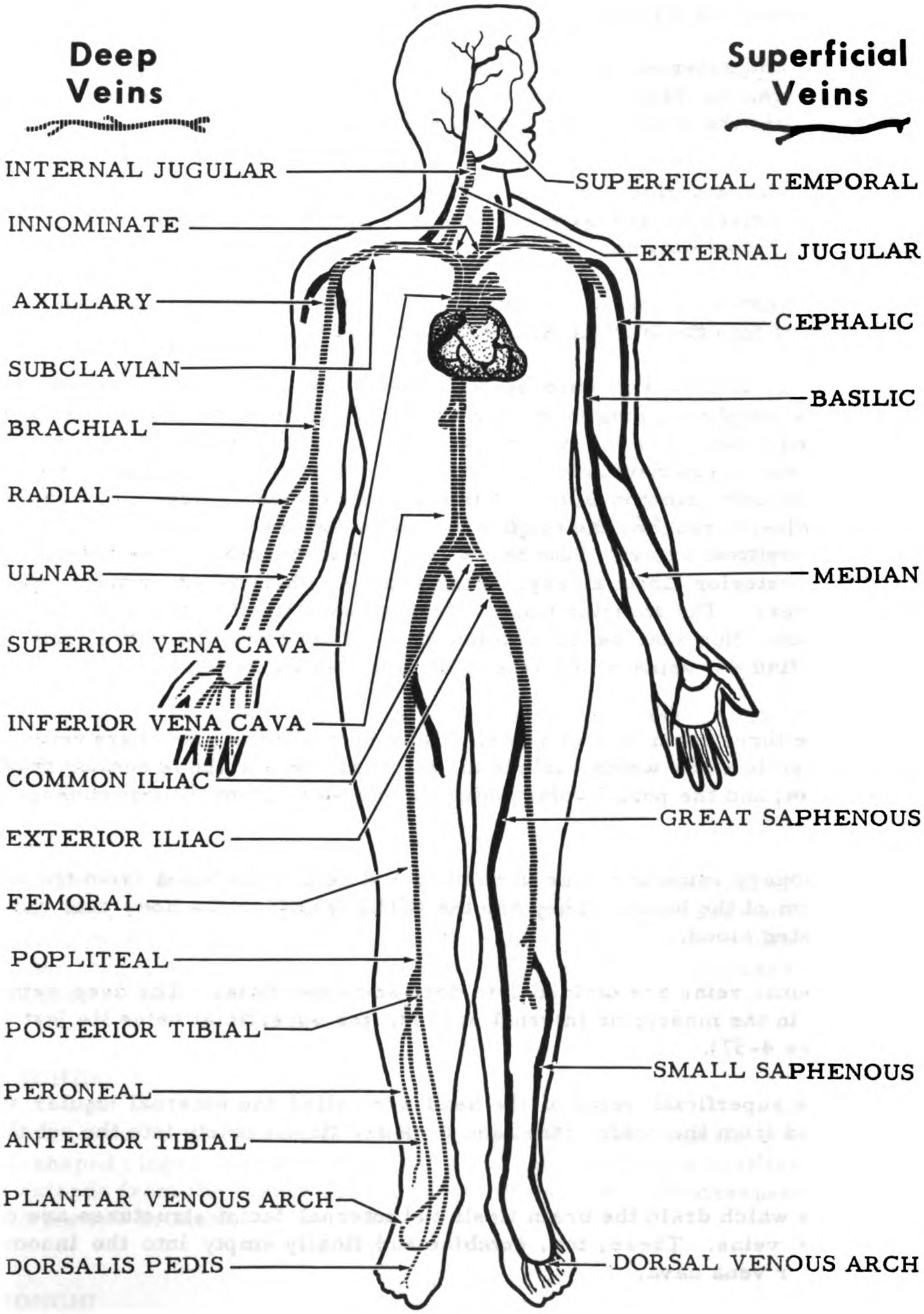



**Figure 4-37 Major Veins**

The next branch is the left common carotid, which supplies the left side of the head. The third branch from the arch of the aorta is the left subclavian artery which supplies the blood to the left arm.

As the carotid arteries run up the head they divide so that they have an internal and an external branch. The internal carotid supplies the brain and eye. The external carotid supplies the muscles and skin of the face.

The subclavian arteries are so named because they lie under the clavicle. They supply the upper extremity and give off branches to the back, chest, neck and even the brain via the spinal column.

The larger artery going to the arm is called the BRACHIAL ARTERY. This eventually divides into the ULNAR AND RADIAL ARTERIES.

The aorta as it passes through the chest is called the thoracic aorta and gives off branches that supply the lungs and chest wall. As it passes through the diaphragm into the abdomen it becomes the abdominal aorta. This supplies the stomach, intestines, liver, spleen, kidneys, etc. In the pelvis region the abdominal aorta divides into the right and left common iliac arteries which send large branches down to the extremities. When it reaches the thigh it becomes the femoral artery. Lower down it becomes the popliteal artery. Just below the knee it divides into the anterior tibial artery and the posterior tibial artery. The posterior tibial artery divides again into the peroneal artery. The anterior tibial artery extends itself into the dorsalis pedis artery of the foot. Now that we have followed the main branches of the aorta to the foot we have to find the veins which return the blood to the heart.

There are three main sets of veins. These sets are the pulmonary veins in the lungs, the systemic veins which include all the veins except those coming from the digestive system, and the portal veins which return blood from the intestines, spleen and liver.

The pulmonary veins are four in number and return the blood from the lungs to the left atrium of the heart. They are the ONLY VEINS in the body that carry freshly oxygenated blood.

The systemic veins are divided into deep and superficial. The deep veins are usually located in the muscle or internal organs; the superficial veins lie just under the skin (Figure 4-37).

The large superficial veins of the head are called the external jugular veins. They drain blood from the scalp, face, and neck and finally empty into the subclavian veins.

The veins which drain the brain itself and internal facial structures are called internal jugular veins. These, too, combine and finally empty into the innominate vein and superior vena cava.

The superficial veins of the upper extremity begin at the head and extend upward. There is one set of veins with which you should be familiar called median cephalic or median basilic veins that cross the elbow. These are the veins that you have to use to inject material into the arm.

In the lower extremity there is a superficial vein called the saphenous, which starts on the inner side of the foot and runs up the inside of the leg and thigh to join the femoral vein in the groin. This vein is sometimes used at the ankle for intravenous injections. The femoral vein is the large deep vein of the thigh.

The portal system of veins is that which drains the blood from the stomach, liver, intestines, spleen, pancreas, gallbladder, etc. It empties into the inferior vena cava.

## RESPIRATORY SYSTEM

Respiration, or breathing, is taking air into the lungs to obtain oxygen in exchange for carbon dioxide, which is exhaled. In man the respiratory organs are the nose, the mouth, the pharynx, the larynx, the trachea, the bronchi, and the lungs. Accessory organs that make breathing possible are the thorax, the ribs and the diaphragm.

Air enters the nose and nasal chambers, where it is filtered by little hairs or CILIA. These take out dust particles that would irritate the lungs. The chambers of the nose also warm and moisten the inspired air. The air then passes through the back part of the mouth, where it is moistened even more.

### THE PHARYNX

The pharynx is the passageway between the nasal chambers, the mouth and the larynx.

### THE LARYNX

The larynx, or voice box, is just below the pharynx, and helps to form your "Adam's apple". It is pulled upward against the base of the tongue and closed when you swallow, to keep food from entering the lungs. All air must pass through the larynx to the lungs, and air passing from the lungs to the larynx makes sound, which we call speech or singing.

### THE TRACHEA

The trachea, or windpipe, is a tube formed of ribbed cartilage with fifteen or twenty C-shaped rings. It is lined with cilia and mucous glands to filter out dust and dirt. It extends from the larynx down to about the second rib interspace where it divides into the two bronchi.

### THE BRONCHI

The bronchi are branches from the trachea like the main large branches from the trunk of the tree. These bronchi break out into smaller twigs known as BRON-

CHIOLES. At the end of these bronchioles are little air sacs that could represent the leaves of the tree. The air sacs are called ALVEOLI. These little sacs exchange the oxygen and carbon dioxide.

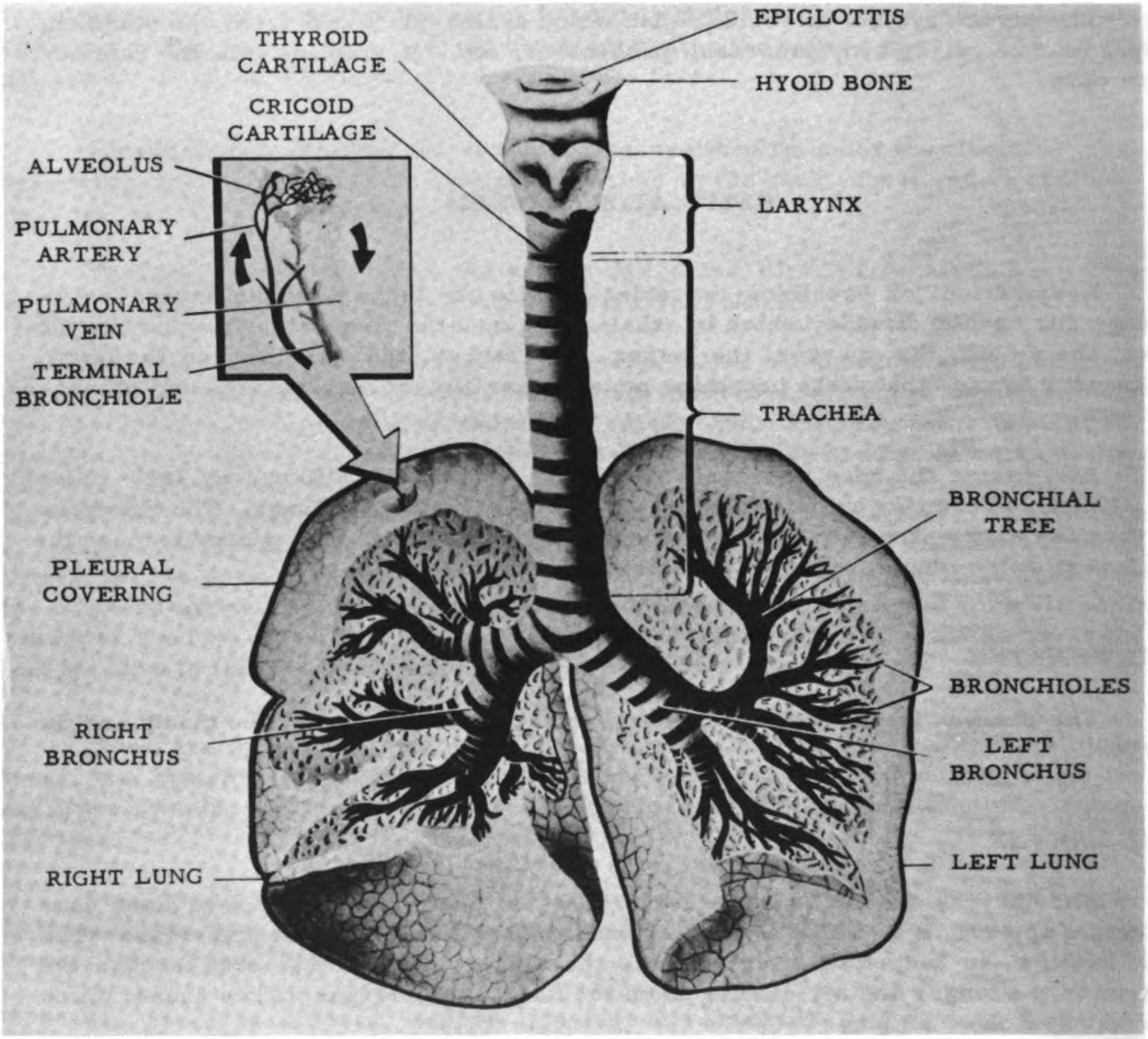



Figure 4-38 Respiratory System

## THE LUNGS

The lungs are like two large sacs which are divided into lobes. Each sac contains thousands of tiny alveoli with blood capillaries lining their membranes.

The right lung has THREE lobes. They are the superior, middle and inferior lobes. It is also shorter than the left lung because of the liver. The left lung has only TWO lobes. They are the superior and inferior lobes. The medial portion of the left lung is indented due to the position of the heart. Each lung has an apex at the top and a base at the bottom. The size of lungs depends on the body type of the indi-

vidual. A short, heavy man will have a short lung field. A long, slender man will have a long lung field. You will find out more about the body types later on.

Each lung is encased in a serous membrane called the PLEURA. This lining is smooth and has a small amount of fluid in it to prevent the lungs from rubbing against the chest wall. When this lining becomes infected you have a condition known as pleurisy. It is quite painful and breathing is difficult.

### THE PROCESS OF RESPIRATION

The movements of breathing are controlled by the respiratory center in the brain. Nerves pass down from the brain through the neck to the chest wall and the diaphragm. The respiratory center is stimulated by chemical changes in the blood. The muscles of the system normally act automatically, but as you know, they can be controlled voluntarily to some extent. The respiratory cycle is the inspiration and expiration of air.

The normal respiration is fourteen to eighteen cycles per minute. In the act of inspiration the diaphragm contracts, the ribs are elevated, and a negative pressure is produced in the lungs. This draws air into the lungs to equalize the outside pressure. In expiration the diaphragm relaxes and the elasticity of the lungs plus the weight and elasticity of the chest walls, forces the air from the lungs.

The lungs, when filled to their capacity, will hold about 4,500 cc. of air. However, only about 500 cc. is breathed out in a normal quiet expiration. Under normal conditions there is a reserve supply of 2,600 cc. of air in the lungs at all times.

## THE DIGESTIVE SYSTEM

The digestive system is the alimentary canal. It begins at the lips and ends at the anus. The accessory organs of the system are the salivary glands, liver, pancreas and gallbladder. The digestive system carries food so that digestion and absorption can occur, and it eliminates waste material. The secretions of the accessory organs help prepare the food for absorption and use by the tissues of the body. The alimentary canal is about twenty-eight feet long (Figure 4-39).

### THE MOUTH

In the mouth the food is broken into small pieces by the teeth. It is mixed with saliva from the salivary glands as the beginning of the digestive action. This saliva moistens the food, making it easier to chew and aiding the act of swallowing by lubricating the food mass.

### THE PHARYNX

The pharynx is a passageway for both the food and air.

## THE ESOPHAGUS

The esophagus is a long muscular tube about ten inches in length. It lies in the center of the body in front of the aorta but behind the heart. By means of muscular contractions, known as peristalsis, food is pushed into the stomach. When food is pushed back up the esophagus it is called vomiting.

## THE STOMACH

The stomach is a large muscular bag located in the upper middle and left sections of the abdomen. The esophagus enters the stomach near the top. Between the esophagus and the stomach is the cardiac orifice. Above this orifice is a part of the stomach called the fundus. The fundus is the round upper part of the stomach. The area between the fundus to the pyloric portion is the body of the stomach. The lower portion, as it goes into the intestines, is called the pyloric region. The pyloric orifice divides the stomach from the first part of the small intestine. Both the cardiac and the pylorus orifices are guarded by a sphincter type of muscle. This muscle could be compared to your fingers squeezed around the neck of a cloth bag.

The stomach is almost always curved upon itself. A line that is followed from the cardiac orifice on the top of the stomach to the pyloric region is the lesser curvature. The line running on the outside of the bottom of the stomach is the greater curvature of the stomach.

The stomach holds the food while it churns the food and breaks it down into a semi-liquid state with its digestive juices. Every now and then it allows some of this to pass through the pyloric sphincter into the first part of the small intestine. After the first hour a meal is half gone from the stomach. At the end of the sixth hour the stomach is empty of a meal. Generally, the time required will depend upon the type of meal taken, whether liquid or solid.

## THE SMALL INTESTINE

From the stomach the food reaches the small intestine. The intestine is made up of three sections, the duodenum, the jejunum and the ileum. It is about twenty-three feet long.

The duodenum is the first part of the small intestine. It is about ten inches long and is formed like a "C" under the liver and over the head of the pancreas. The pancreas, liver and gallbladder have ducts into this part of the small intestine. The secretions from these organs help to further the digestion of the food. It ends about the level of the second lumbar vertebra.

The jejunum is the second portion of the small intestine. It is about seven and one-half feet long.

The ileum is the last section of the small intestine and is the longest section. It is formed in numerous coils and connects to the large intestine at a right angle. Between the ileum and the large intestine is the ileocecal valve. This valve keeps the waste products of digestion in the first section of the large intestine so that it cannot back up in the ileum.

In the stomach and the small intestines the digestive process of food is completed.

It usually takes from twenty minutes to two hours for the first meal to pass from the stomach to the end of the ileum. After six hours most of it will be in the large intestine and in twelve hours all of it should be out of the ileum.

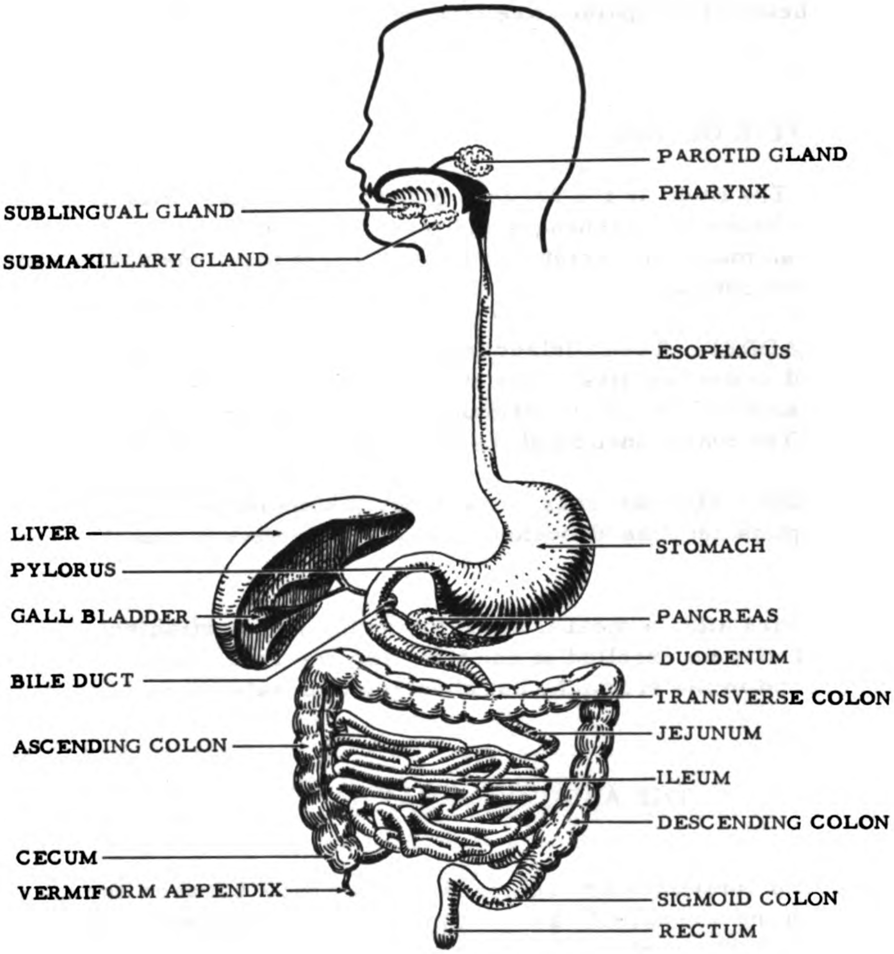



Figure 4-39 Digestive System

## THE LARGE INTESTINE

The large intestine is made up of the CECUM, ASCENDING COLON, TRANSVERSE COLON, DESCENDING COLON, SIGMOID COLON, RECTUM, ANAL CANAL AND ANUS.

As the food waste material and water pass through the ileocecal valve it enters the cecum which is the lower part of the ascending colon. Attached to the bottom of the cecum is the appendix. The material is forced up through the ascending colon.

The ascending colon is on the right side of the body. This is the portion of the alimentary canal where most of the water needed by the body is absorbed. The ascending colon comes to a corner called the hepatic flexure because it is directly under the liver. Here it becomes the transverse colon and cuts across the body to the left where it again makes a sharp downward turn. This turn is called the spleenic flexure because it lies under the spleen. This downward section is called the descending colon. When it reaches the bottom of the descending colon it enters a section called the sigmoid or S-shaped colon. From the sigmoid colon the material passes into the rectum where it is held until impulses are felt which cause it to be expelled through the anus.

### ACCESSORY DIGESTIVE ORGANS

THE LIVER. The liver is the largest gland in the body. It is located in the upper right side, just below the diaphragm and right lung and above the duodenum and the lower end of the stomach. It performs many different functions besides aiding in producing digestive secretions.

THE GALLBLADDER. The gallbladder is a dark green sac, shaped like a small blackjack and located under the liver. Its duct, the CYSTIC DUCT, joins the duct from the liver, the HEPATIC DUCT, to form the COMMON BILE DUCT which empties into the duodenum. The main function of the gallbladder is to store bile.

THE PANCREAS. The pancreas is a long, pistol-shaped gland lying behind the stomach. It empties into the duodenum and has digestive juices that act on all types of food.

Twenty-four hours after a meal is eaten the undigested portion should be in the rectum. A part of it may be expelled at one time and the rest at another. There is little absorption of food in the stomach, but absorption of water does occur.

## THE ABDOMINAL CAVITY

The stomach and intestines are enclosed in the space between the diaphragm and the pelvis, called the abdominal cavity. This cavity is lined with a serous membrane, the peritoneum. The peritoneum covers the intestines and organs and by secreting a serous fluid prevents friction between the organs that are side by side. Layers of the peritoneum that extend from the body wall to an organ and suspend it are called mesentery. The mesentery carries blood vessels to the different organs. Folds of peritoneum lie in front of the abdomen connecting the stomach, liver, and parts of the intestines. These are called OMENTA.

## THE URINARY SYSTEM

### THE KIDNEYS

The kidneys are two large, bean-shaped organs designed to filter waste ma-

terials from the blood. They are located in the upper part of the abdominal cavity, but are OUTSIDE OF the peritoneal sac. There is one on each side of the vertebral column. The upper end of each kidney reaches above the level of the twelfth rib. They occupy a space from the twelfth thoracic to the third lumbar, generally. They measure about 4-1/2 by 1-1/2 inches.

The kidney has an upper layer of pale tissue called the cortex and a darker layer known as the medulla. The medulla appears as triangular areas below the cortex. These areas are called the medullary pyramids. Within the cortex and medulla are great numbers of filtering units called nephrons. These numerous individual tubular units filter the blood, saving products still needed and disposing of waste products. The filtered wastes pass from the nephron units to the KIDNEY PELVIS. This renal pelvis is the dilated part of the ureters that are attached to the hollow side of the kidney (Figure 4-40).

## THE URETERS

There are two ureters, one from each kidney. They are membranous tubes about fifteen to eighteen inches long. Passing from the kidneys they go down the back of the abdominal cavity to the urinary bladder.

## THE BLADDER

The urinary bladder is musculomembranous sac that is found in the lower part of the pelvis just above the symphysis pubis. It acts as a reservoir for the urine.

## HOW THE KIDNEYS WORK

The kidneys are effective blood filters. They filter waste materials from the blood and excrete them in a watery solution known as urine. They also play an important role in keeping the reaction of the blood normal, making sure that it does not get too acid or too alkaline. The normal blood reaction is slightly alkaline. They do this by excreting enough substances from the blood to maintain this alkalinity. For example, if the blood becomes too acid they will excrete acid in the form of salts; on the other hand, if too alkaline they will excrete alkaline salts.

The kidneys also remove excess sugar present in the blood, but the main job of the kidneys is to excrete nitrogenous waste products which are produced in the breakdown of proteins.

Besides filtration, the second important function of the kidneys is reabsorption of water, salts, sugar, and protein elements of the blood. This selective reabsorption keeps the blood at an acid-base balance and also a constant concentration of water, salts and proteins. This delicate balance is essential for normal life. Controlled reabsorption accounts for the amount of urine which is finally passed from the kidneys, for the nephron filters gallons of blood each day. It is estimated that 10,000 quarts of blood pass through the kidneys in twenty-four hours and about eighty gallons of urine is formed, but all of the water from this urine is reabsorbed in the kidney tubules except that containing concentrated waste products. The amount of urine excreted by a normal adult is from 1,000 to 1,500 cc. per day. You will be required to examine the urinary system quite frequently.

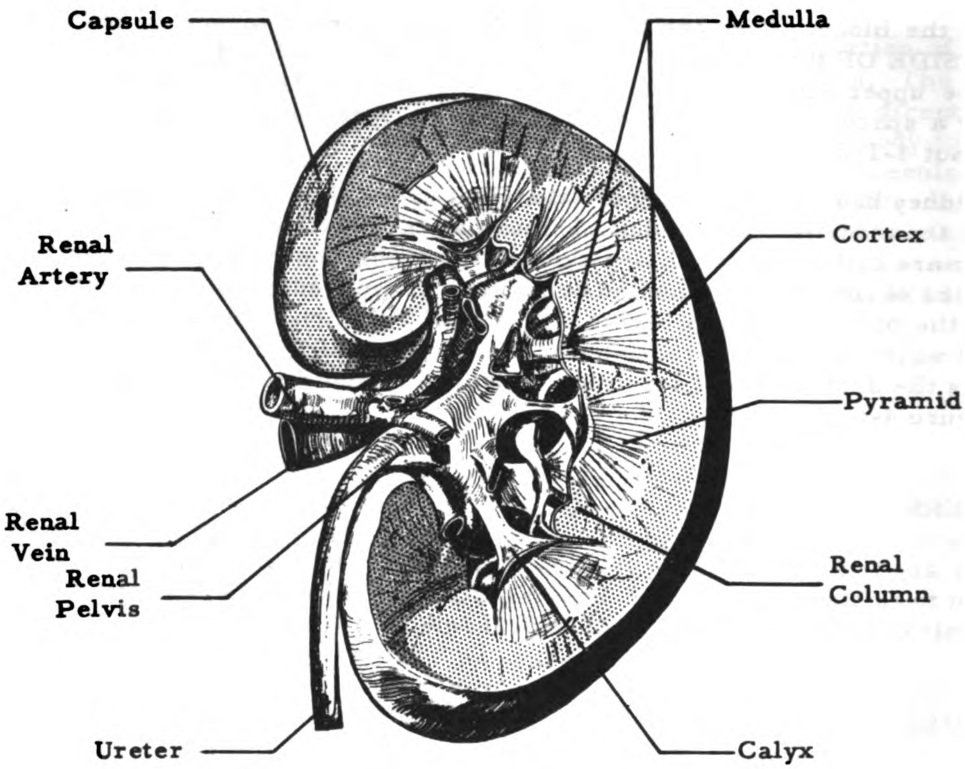



Figure 4-40 Kidney

## CENTRAL NERVOUS SYSTEM

Your central nervous system is the telephone system of your body. The brain is the switchboard in the main office, the spinal cord is the main trunk line that carries the messages from the individual lines we know as the nerve fibers. It is a most complex system and many of its mysteries have not been revealed as yet. As an X-ray technician you will be more concerned with the various spaces and cavities in the system (Figure 4-41).

### THE BRAIN

The brain is the center of communication. It is the biggest mass of nerve tissue in the body. The brain consists of five recognizable parts. They are the cerebrum, the midbrain, the cerebellum, the pons, and the medulla oblongata.

### THE CEREBRUM

The cerebrum is the biggest part of the brain. It fills up most of the upper part of the skull cavity. This is the part of your brain that controls your reason and memory. It also causes you to laugh or cry. It does have a number of other important

functions which you can learn through further study. The cerebrum is divided into lobes. These lobes are usually named for the bone of the skull that they are adjacent to, such as the temporal lobe, frontal lobe, etc. You can compare the brain to a potato sack that is almost filled with potatoes. It is bumpy with many grooves and fissures. If you pick the sack up from the bottom it will curl so that it leaves a sort of hollow spot underneath. There is a deep groove through the center of the brain which divides it into two hemispheres. Filling the underside of the hollow is a wide, transverse band of white tissue called the corpus callosum. Lying under the corpus callosum you will notice a series of cavities that are filled with cerebrospinal fluid. These are called the ventricles of the brain.

## THE VENTRICLES

There are four ventricles in the brain. Two of them are lateral ventricles. The uppermost parts of the lateral ventricles are found about three inches above the external acoustic meatus. They have an anterior and posterior horn and resemble a wishbone of a chicken placed vertically. The anterior horn reaches forward approximately to the coronal suture. The posterior horn is variable.

The third ventricle is beneath and slightly behind the lateral ventricles. It is connected to the lateral ventricles through two tiny foramina called Foramina of Monro. It is crescent-shaped and also holds fluid.

The fourth ventricle is below and posterior to the third. It has a triangular shape with the apex connected to the third ventricle. The communication between the third and fourth ventricle is through a small canal known as the Aqueduct of Sylvius. On the top of the fourth ventricle are three tiny openings which allow the cerebrospinal fluid to flow into the subarachnoid space. (The subarachnoid space is a space between the tissues which coat the brain and spinal cord). The fluid bathes the spinal cord and brain.

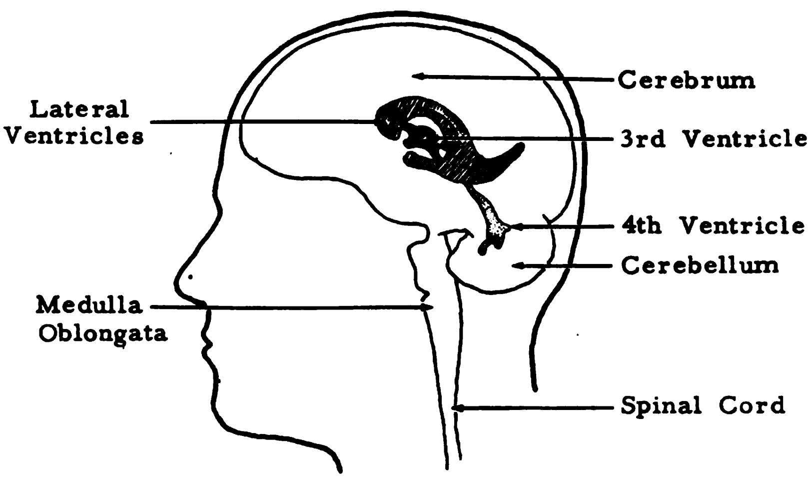



Figure 4-41 Central Nervous System

As an X-ray technician you will be demonstrating these ventricles in the various diseases of the brain. Some of the fluid is drained by spinal puncture and replaced with air which will show up dark on an X-ray film. Any displacement or eaten away appearance of these ventricles may indicate some type of pathology.

THE MIDBRAIN. The midbrain is found just behind the ventricles and connects the pons and the cerebellum to the cerebrum.

THE CEREBELLUM. The cerebellum is the center for muscular coordination. It lies behind the midbrain and below the cerebrum in the back lower part of the skull.

THE PONS. The pons is a little nut-like structure below the ventricles and in front of the cerebellum. It acts as a point of union for the cerebellum, cerebrum and medulla oblongata.

THE MEDULLA OBLONGATA. The medulla oblongata is situated down from the pons and at the lower anterior portion of the cerebellum. It spreads out at the upper end into a pyramid shape. The top of the spinal cord passes down through the foramen magnum of the occipital bone to connect with the cord. It is the source of control for the heart and breathing apparatus of the body.

THE MENINGES. The brain and spinal cord are coated with three membranes. On top is the dura mater, the middle layer is the arachnoid mater, and the innermost layer is the pia mater.

THE SUBARACHNOID SPACE. The subarachnoid space is between the arachnoid and pia mater.

THE SPINAL CORD. The spinal cord is found in the vertebral column. It is about eighteen inches long. The spinal cord becomes smaller as it comes down the vertebral column but does enlarge in two places - in the cervical region and the lumbar region. In these regions the cord sends nerves out to upper and lower extremities. The cord ends about the second lumbar vertebra in the CAUDA EQUINA or horse's tail that you have read about before.

## REPRODUCTIVE ORGANS

### THE MALE REPRODUCTIVE ORGANS

The essential male organs of reproduction are the penis and testes (testicles). The testes are held in a sac of skin called the scrotum. The male or sperm cells are formed by the testes. They pass into coiled tubular structures called the epididymis, where they are stored. They next travel through long narrow tubes, the ducti deferentia (vas deferens), to short ejaculatory ducts which end in the urethra.

THE TESTES. The testes are oval glands suspended in a sac of skin, the scrotum, by the spermatic cord. The epididymis is a division of the testes just outside of the gland that stores the sperm cell and eventually transmits them to the ductus deferens (Figure 4-42).

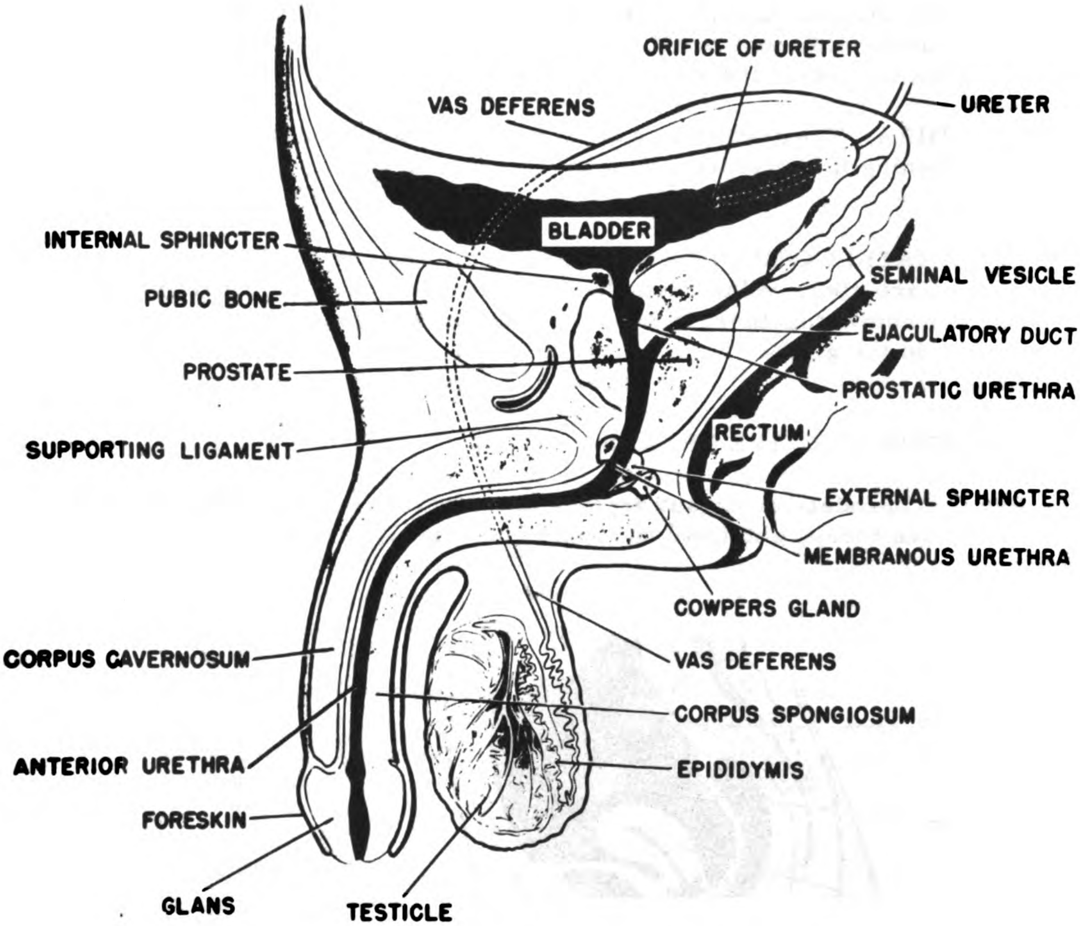



Figure 4-42 Male Reproductive Organs

THE DUCTUS DEFERENS. (VAS DEFERENS). The ductus deferens is a tiny tube that extends from the epididymis up through the inguinal canal (under the crease of your thigh or groin) toward the bladder. It carries the sperm cells into the ejaculatory duct, through which they pass to the urethra.

THE SEMINAL VESICLES. The seminal vesicles are two pouches that lie between the bladder and the rectum, and unite with the ductus deferens to form the ejaculatory duct. The vesicles secrete and store a fluid to be added at the time of an ejaculation to the secretion of the testes.

THE EJACULATORY DUCT. The ejaculatory duct is a short tube that leads into the prostatic urethra. During sexual intercourse sperm cells from the ductus deferens and fluid from the seminal vesicles are discharged into the ejaculatory duct. The ejaculatory duct then contracts and discharges these substances into the urethra.

THE PROSTATE GLAND. This gland is made up of smooth muscle and glandular tissue that surrounds the first section of the urethra. It resembles a horse chestnut in size and shape. The prostate gland secretes an alkaline fluid to keep the sperm mobile and protect them from the acid secretion of the female vagina. This is discharged into the urethra during intercourse.

COWPER'S GLANDS. Cowper's glands are two pea-sized bodies on each side of the membranous urethra and opening into it. They secrete fluid that is chiefly mucous and serves to protect the sperm cells.

THE URETHRA. The urethra is a canal which extends from the urinary bladder to the external opening in the penis. It is the common canal for the urine and semen fluid.

THE SPERMATIC CORDS. The spermatic cords are two cords, each consisting of vas deferens, arteries, veins, lymphatic ducts, nerves and connective tissue. These structures come together in the abdominal cavity and pass into the scrotum through the rings in the groin.

## THE FEMALE REPRODUCTIVE ORGANS

The female reproductive organs include the external genitalia, the vagina, the uterus, the fallopian tubes, and the ovaries (Figure 4-43).

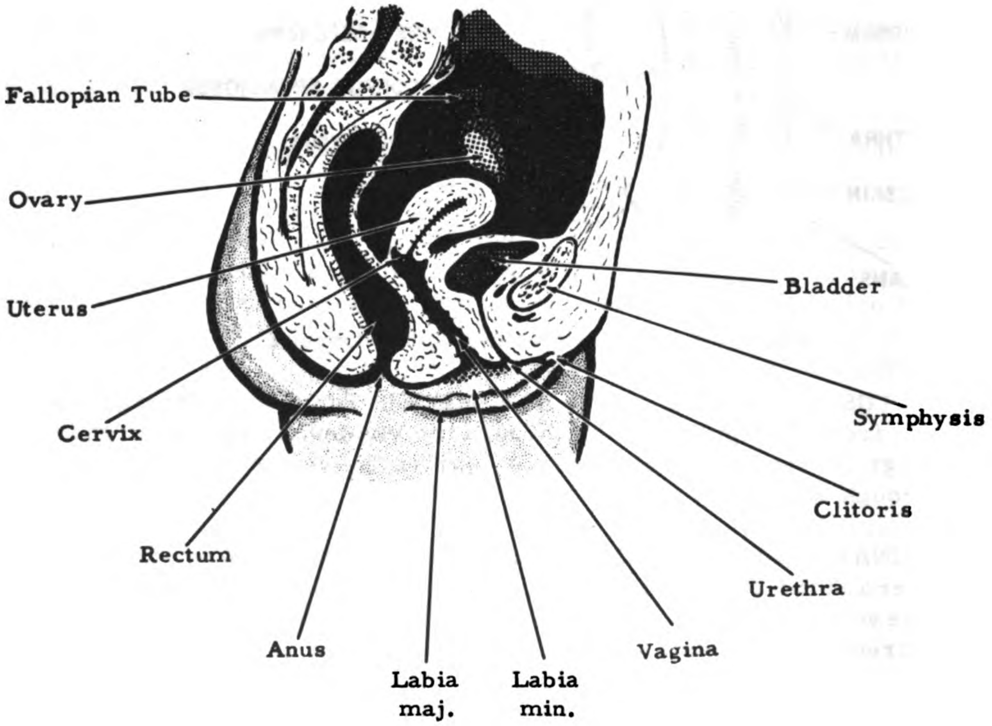



Figure 4-43 Female Reproductive Organs

The part of the female reproductive system that can be seen at the surface of the body is called the vulva. The urethra, through which the urine is voided, opens near the front slit in the middle of the vulva. Behind the urethral opening and below it is the vaginal opening. The vagina is a broad muscular tube that averages about

four inches in length. It leads up to the mouth and neck of the uterus. This part of the uterus is known as the cervix of the uterus. The uterus is a pear-shaped muscular organ. From the upper corners of the uterus, small tubes extend sideways toward the ovaries. These are the fallopian tubes or oviducts. The ovaries are glands about the size and shape of almonds.

THE EXTERNAL GENITALS. These include the labia majora, which are the folds of skin extending from beneath the mons pubis in front to near the anus. Within these two folds are the labia minor, or minor lips. The clitoris is a small body of erectile tissue and is located at the top where the two labia minora meet. The vestibule is the space between the labia minora into which the urethral and vaginal orifices open, the hymen is a fold of mucous membrane which sometimes is present across the lower part of the vaginal opening. The mons pubis is the fat pad located in front of the symphysis pubis. It is composed of fatty tissue and covered with skin and hair.

THE VAGINA. The vagina is the muscular canal lined with mucous membrane which extends from the cervix or neck of the uterus to the external genitals. The posterior wall is about four inches long and the anterior wall is about three inches long. Its lining membrane is greatly folded and is continuous with the inner lining of the cervix. The vagina is capable of stretching widely to serve as a birth canal during the delivery of a baby.

THE UTERUS. This is a hollow, pear-shaped smooth muscle organ lined with a special type of cell. Normally, it is about three inches long by three inches wide at its upper widest part. There are two openings in its top corners for the fallopian tubes. It has a tube-like canal in the lower portion called the cervix that opens in the vagina.

THE FALLOPIAN TUBES. These are two musculomembranous tubes which have free openings in the lower abdominal cavity near the ovaries and terminate by opening into the uterus. Their free ends are shaped like a funnel, surrounded by fingerlike processes designed to help the ovum or egg, when it is released by the ovaries, to find its way into the tube and down to the uterus.

THE OVARIES. The ovaries are two almond-shaped glands suspended by ligaments in the lower abdominal cavity, one on either side of the uterus. Their prime function is to produce the ova and female hormones that are necessary for maintaining the menstrual cycle. There is a menstrual discharge of blood and other substances from the unfertilized uterus every twenty-eight days in most women.

As an X-ray technician you may find that you will be doing more examinations of the female reproductive organs than those of the male. However, they are not frequent.

## ENDOCRINE SYSTEM

The endocrine system is made up of glands of internal secretion, called ductless glands because they have no ducts to carry away their secretion. The secretion of these glands are called hormones. Some of them influence the body as a whole. The hormone-producing glands are the THYROID, PARATHYROID, ADRENALS, PITU-

ITARY, GONADS (male testis; female ovary), PANCREAS, PINEAL BODY AND THYMUS.

THE THYROID. The thyroid gland sits like a butterfly in the front part of the neck just below the "Adam's apple". It has two lobes connected in the middle by a strip of tissue called the isthmus. The hormone secreted by the thyroid is thyroxin. This hormone regulates the metabolism of the body. (Metabolism is the amount of "burning" of the body, or the rate of "living" being done by body tissues). You will see frequent cases that involve the thyroid gland.

THE PARATHYROID. Parathyroid glands are four in number. They are small, round and located beneath the thyroid gland. They regulate the amount of calcium and phosphorus in the blood.

THE ADRENAL GLANDS. The adrenal glands are sometimes referred to as suprarenal glands, since they sit like small cocked hats on the top of each kidney. They consist of an inner portion called the medulla and an outer portion called the cortex. They produce adrenalin. This is the hormone which gives the body that extra push in fear or anger, sometimes called the "fight-or-flight" hormone.

THE PITUITARY GLAND. The pituitary is a small pea-sized gland located at the base of the brain. It sits in the sella turcica of the sphenoid bone. It controls all the other endocrine glands in the body. It has two lobes; the anterior and posterior. The anterior lobe is the leader with many different functions attributed to it.

THE GONADS. These are the sex glands. The ovary in the female and the testes in the male produce hormones which give us the sexual characteristics of pubic hair, beards on men, and breasts on women.

THE PANCREAS. This gland gives off the insulin that you have heard so much about for treatment of sugar diabetes. Insulin is essential for the storage and use of carbohydrates by the body.

THE PINEAL GLAND. This is a small gland located near the roof of the brain at the back of the corpus callosum. It is thought that this gland exerts influence on the rate of growth of the body and the onset of puberty. The pineal body is sometimes found to be calcified in the adult. It can be seen right in the middle of the head, and if it is shifted in position, can indicate the presence of a growth in the brain.

THE THYMUS. The thymus is an organ located in front of the trachea, partly in the neck and partly in the upper part of the thorax. It is large in infancy and shrinks as the individual matures. Little is known about this gland.

## SUMMARY

You have now covered the anatomy of the human body. It is not as complete as the doctor must know it and some of the knowledge will be infrequently used, but you have a fundamental jumping-off place for more learning as you progress. You should know the bones of the body very thoroughly. You should have some knowledge of how your heart works, how you breathe and what your urinary, digestive, nervous, re-

production and endocrine systems are. You have just started to learn anatomy. In the chapters that follow you will find out about the different types of body-build and something about the difference in sex characteristics that will affect your X-ray films. It is a most important subject to the X-ray technician and one which will make him stand out among others if he learns it well. He will have no fear of locating any structure he is asked to examine.

Ahead of you is the means of actually taking the X-ray film. It is a study of the techniques required to demonstrate this type of anatomy. It is called radiographic technique. In it you will learn what the four prime factors are, what exposure mathematics are used, some of the auxillary equipment you will encounter and how to develop and use technique charts. The material you will learn in the next chapter will take time to develop but if you will try with everything you have you will become excellent at using radiographic technique.

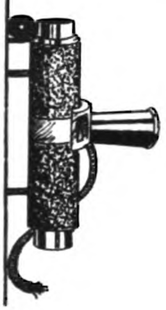
## WORK PROBLEMS

1. Take a series of X-ray films of the various parts of the body and identify as many structures as you can in each film. Number these structures with a wax pencil by using the text. Then close the text and see how many you can identify.

2. Use a buddy and try to find the structure of the radiograph on his body. Review the text and try to identify the structures in the illustrations after blocking out the identification.

3. Write each bone of the body down on a sheet of paper. Under each bone heading write the structures that you can remember. Turn to your text and see how many of them you left out.

4. Go to the hospital library and find some anatomy books. Brouse through them to see how the various books picture the structures.



# CHAPTER 5

## RADIOGRAPHIC TECHNIQUES

You should be well acquainted by this time with the X-ray machine, the properties of X-ray and how to protect yourself from it. You are also aware of the human body and its structures. In this chapter you are actually going to learn how to use the X-ray beam. You will learn about the auxillary equipment you will need, the geometric patterns of X-ray, and how to determine the amount of X-ray you need to get an X-ray film. This chapter will not be difficult if you read it carefully. More than likely you have already had the experience of taking a photograph. You will be learning how to take something like a photograph with X-ray. You will select your camera, lens, exposure factors, filters and other equipment necessary to get your picture. A comparison of photography and X-ray is simple. You use light to expose your photographic film. In X-ray you will use the X-ray beam. In photography, you use a camera; in X-ray you will use an X-ray tube. So as you see you have a very common ground on which to begin your study of radiographic technique. There will be a few additions that are exclusive to X-ray but the similarities are many.

To begin your study on radiographic technique you will be given the essential background necessary for you to understand and apply radiographic technique in your work. The first thing, then, is to understand the .............

### FACTORS IN RADIOGRAPHIC TECHNIQUE

The four prime factors in X-ray are kilovoltage peak (KVP), milliamperage (MA), time (T), and distance (D). (Figure 5-1). You can control these factors mechanically from the control panel and tube column. A combination of these four factors are necessary in ANY X-ray you will ever take. The proper use of these factors determines the quality of your radiograph. It must be kept in mind that you are not taking a "photograph" of the body structures, but a "shadow-graph" of the parts. All the X-rays do not pass through a part. Some are stopped by the bone, etc. If you place your hand in front of a light you see only the shadow outlined. The same is true with X-ray. You really see only the shadow of the bone or tissue.

## KILOVOLTAGE PEAK (KVP)

KVP is the factor which determines the QUALITY of the X-ray beam (Figure 5-2). In your first chapter you found out that the X-ray beam has many different wave lengths. Some of the wave lengths are short, some are medium and others are long. This type of beam, with all the different wave lengths, is known as a HETEROGENEOUS beam. If it were possible to get an X-ray beam with only one size of wave length it would be a HOMOGENEOUS beam.


Figure 5-1 Four Prime Factors

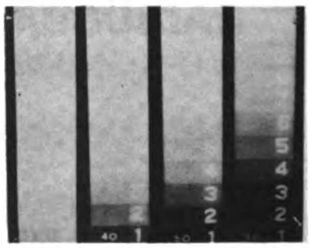


Figure 5-2 KVP Determines Quality

You will also remember that the shorter the X-ray wave length, the GREATER THE PENETRATION OF THE OBJECT. In radiation work you have to penetrate the parts of the body with X-rays. X-ray penetration is controlled with the KVP. The higher your KVP is, the more short wave lengths you will have in your X-ray beam. It is the number of short, penetrating wave lengths in a beam of X-ray that determines the quality of that beam.

The size of the structure and the composition of the tissue that makes up that structure determines how high a KVP you will use. You will not need as much penetration for the thin hand as you will need for the pelvis region.

## MILLIAMPERAGE AND TIME (MAS)

Milliamperage is combined with time and gives you a specific amount of X-ray (Figure 5-3). MAS is the quantity of X-ray or milliamperage times seconds. You can think of it as the light that exposes your X-ray film. Let's try to illustrate this. When you turn on your X-ray machine and set it at a certain MA, say 100 MA, you can picture in your mind that there are 100 little electrons flying off the filament every second. The time is actually the time that the KVP is shoving these electrons over to the target. Without the KVP the electrons will just hover around the filament. So if you apply KVP to the filament for a period of one second you will shove off 100 electrons. If you apply the KVP for a period of two seconds, you will, in that time, shove off 200 electrons, 100 for each second of time. Now, however, if you only apply your KVP for 1/2 second you will only send 50 of the 100 electrons across to the target.

100 MA x 1 second = 100 MAS

100 MA x 2 seconds = 200 MAS

100 MA x 1/2 second = 50 MAS

Now imagine that each of these electrons, as they strike the target of the X-ray tube, is made into one X-ray. This will let you see that 100 MA times 1 second will produce 100 X-rays, 200 MA times 2 seconds will produce 400 X-rays and 25 MA times 1/2 second will produce 12.5 X-rays. By controlling MA and time you control the quantity of X-ray.

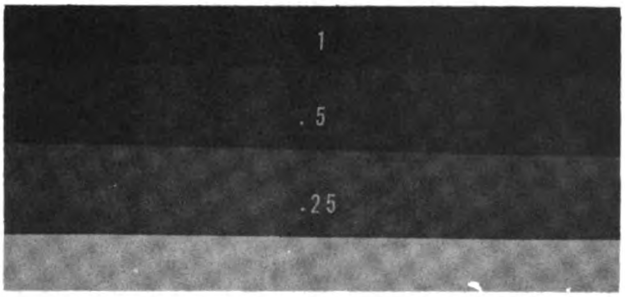



Figure 5-3 MA and Time Determine Quantity

But remember it is the KVP that determines just how many of these X-rays will get through to the film. You may be producing 100 X-rays, but maybe only 30 of them will pass through the object. It is the KVP that determines their wave length and pushes them through a structure.

DISTANCE (D)

Distance is the space between the target or focal spot of the tube and the film under the part. In X-ray you will refer to it as the FOCAL-FILM DISTANCE (FFD). It is very important in the production of an X-ray film. It will determine how sharp your image on the film is, how dark your film becomes, and how much push or KVP is needed to get the X-ray to the film. Later on you will learn more about the effect of distance.

THE INVERSE SQUARE LAW. It is here, then, that you must become aware of the prime law in the use of X-ray radiation. This law is known as the Inverse Square Law. This is of great importance in selecting the combination of KVP, MA, T, and D. Read this carefully and roll this information around in your mind until you grasp the concept and can understand completely. Do not go on until you KNOW this law.

The Inverse Square Law states that the INTENSITY OF THE X-RAY BEAM IS INVERSELY PROPORTIONAL TO THE SQUARE OF THE DISTANCE (Figure 5-4).

Intensity. Intensity in the law refers to the "amount" of X-ray reaching a certain area. It is like the intensity of the heat of the sun. In the summer it is very hot and in the winter it is colder. If you have a bare light bulb handy, place your hand close to it. Now move your hand farther away. You will feel the difference in the intensity of the heat on your hand.

Proportion. Proportion refers to the comparison of the portions of two articles. If you have a ball one inch in diameter and another one three inches in diameter, the larger ball will be three times as large as the smaller one. Take a nickel and a fifty cent piece and place them side by side. You can see that there are more "portions"

so to speak, in the fifty cent piece. Now if it took three nickels to make the same size as the fifty cent piece you would have a proportion of 3:1 (3 to 1). Take this concept now of proportion to the term "direct" proportion. This term is necessary to enable you to fully understand "inversely proportional".

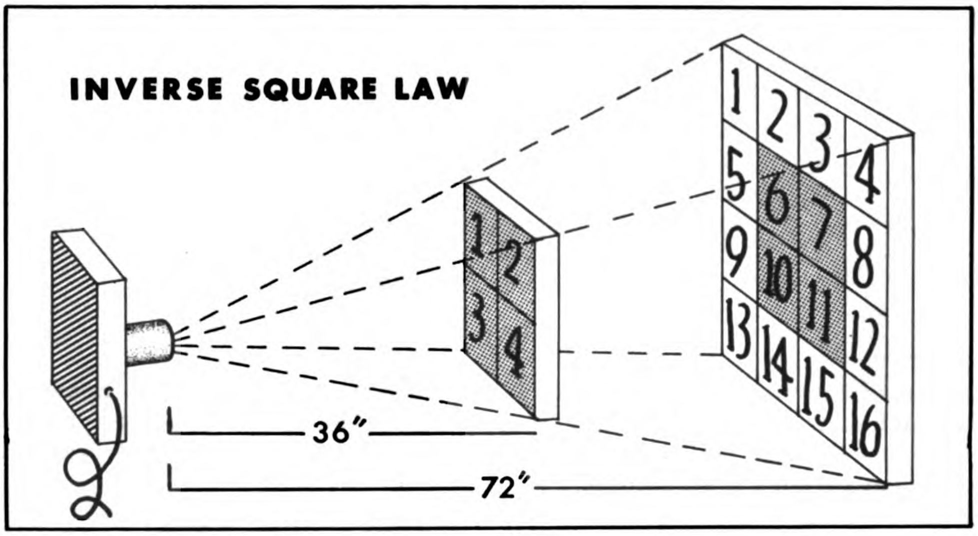



Figure 5-4 Inverse Square Law

Direct Proportion. Direct proportion means that the two articles under comparison will increase or decrease in size directly in accordance with their first proportion. For instance, if you double the size of a fifty cent piece so it would become the size of a silver dollar, your nickel would double its size to that of a quarter right along with the fifty cent piece. Using the ball illustration again, if the small ball is increased to a diameter of two inches, the larger ball would increase its diameter to six inches. As you see there is still the proportion of 3:1. You can divide two inches into six inches and find out that there are three lengths of two inches in every six. Draw a line on a piece of paper six inches long. Then take the ruler and mark off every two inches. You will see that there are three sections in that six-inch line. Now right below the six-inch line draw a line two inches long. Compare the two and you will see that the top line is three times as long as the bottom. If you doubled each line you will find out that the top line would ALWAYS be three times as long as the bottom line. Direct proportion means, then, that if one thing is increased in size the other thing increases proportionally.

Inverse Proportions. With "inverse proportions" you have the opposite effect. When one thing is increased, the other thing being compared to it is decreased. If a ball with the diameter of three inches were enlarged to a diameter of six inches, a two-inch diameter ball would decrease to one-half its original diameter to one inch. While one ball doubled in size the other ball was reduced to one-half its original size. When you double something you multiply it by two. When you cut something in half you divide by two. So, in an inverse proportion, you are multiplying one article by a certain number and dividing the other article by the same number. Use your ruler again and draw a line three inches long and beneath this line draw one that is one inch long. Now if you double the top line so it measures six inches you will have to divide the one-inch line in half. This will give you a line six inches long and one that is one

half inch long. This is what happens when you have an inverse proportion. You have used the number two on both of the articles. Instead of both doubling their size as in a direct proportion, one is doubled and the other is halved.

Square of the Distance. "The square of the distance" means the number of inches between target and film multiplied by itself. If the distance is thirty inches then the square of 30 x 30 equals 900. The "square of the distance" is 900.

Now let's put all of this together again. "The intensity of the X-ray beam is inversely proportional to the square of the distance." The amount of X-ray striking a certain area will be increased if the distance is decreased. The amount of X-ray striking a certain area will be decreased if the distance is increased. Now remember that this is the SQUARE of the distance, so if you double the distance of your tube you will be DECREASING the intensity of the X-ray beam to one-fourth its original intensity. If this is reversed by cutting the distance to one-half the original distance, the intensity of the X-ray beam would be four times the original intensity. Put this idea into numbers. If you had a distance of 20 inches and 40 imaginary X-rays striking one square inch of the paper you can consider them to be the original distance and intensity. Now if you raised the distance to 40 inches or doubled your distance you would reduce to 10 the number of X-rays on your one square inch of paper. However, if you cut your distance in half to 10 inches you would be striking your one square inch of paper with 160 X-rays, or four times the original intensity. Actually what you do when you raise the distance is to spread those other 30 X-rays over three more square inches of paper so that your X-rays are striking a total area of 4 square inches instead of one. Now when you reduce your distance you are removing those spread out X-rays from the other areas and concentrating them onto this one square inch. (Figure 5-4).

A Practical Experiment. A practical experiment in this law can be performed so that you can "see" something of the law. Go to the flight surgeon or medical supply and ask to borrow a flashlight. Take the light and go into a dark room, either your radiographic room or the darkroom. Turn on the flashlight and shine it on a table or the wall. Now look for these things. Notice that the light emerges as a small cone or beam. Keep in mind that an X-ray beam behaves something like a light beam. Bring your source of light close to the table or wall. Notice that the closer you come to the surface, the brighter that surface becomes and the smaller the area of light. This shows you that intensity, or the brightness of the surface, is increased as you reduce the distance between it and the light. Now if you can get someone to help you, place your light at a distance of 36 inches. Have your helper take a ruler and get the approximate diameter of the light area shining on the wall or table. Now back up another 36 inches from your first spot. Have him measure the approximate diameter of the light area again. You will find that it will be approximately four times as large. After doing this, place your light only 18 inches or one-half the original thirty-six inches and measure again. It will be approximately one-fourth the size of the diameter of 36 inches. Also notice that the light area is not as bright at 72 inches as at 36 and that it is brighter at 18 inches than it is at 36 inches.

You will recall in your chapter on protection that the farther away from the X-ray beam the better off you were. That fact stems from the application of this Inverse Square Law. Now if you understand this law you are ready to proceed in radiographic technique. You will return now to the idea of the four prime factors and what effect they produce on an X-ray film. But keep in mind the role that the Inverse Square Law plays as these effects are explained.

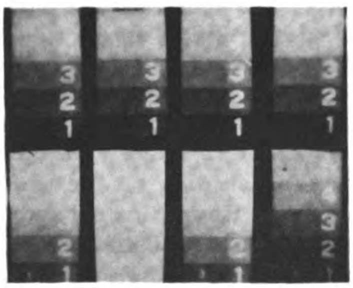
## THE FOUR TECHNICAL FACTORS

There are four technical factors that result from a combination of KVP, MA, T and D. These are DENSITY, CONTRAST, DETAIL AND DISTORTION. Some degree of each one of these factors is present in every X-ray film. It is the object of every technician to provide the maximum of each of these factors, with the exception of distortion which must be minimized. In studying these factors keep in mind the following characteristics of X-ray:

- X-rays travel in straight lines.
- X-rays can pass through matter.
- X-rays cannot be focused to a point.
- X-rays expose photographic film.
- X-rays are absorbed in matter. This absorption depends upon the atomic structure of matter and the wave length of the X-rays.
- X-rays cause fluorescence in certain substances.

DENSITY. The technical factor of density refers to the AMOUNT OF BLACKNESS on a radiographic film. One of the characteristics of X-ray is that it can expose an X-ray film. Light does the same thing in photography. If you use a wide opening on your camera you will get more light which will blacken your film more. In X-ray you use X-ray beams to blacken the film. A dark film will have a high degree of density and a light film a low degree of density (Figure 5-5).

50 MA - 1 Sec.
65 KVP - 36" FFD




| 25 | 72" | 1/2 | 80 |
|---|---|---|---|
| MA | FFD | sec. | KVP |

Figure 5-5 Effect of Four Prime Factors on Density

Density on your film is determined by the number of crystals that are exposed in the emulsion of your film. The number of these crystals exposed is determined by the milliamperage, kilovoltage, time, and distance plus some other factors such as film development that you will learn about later.

The higher the milliamperage the more X-rays you will shower onto the film. The more time you use, the longer the exposure, so more X-rays reach the film. The higher the kilovoltage the greater the penetration, so more X-rays are pushed through the part to the film crystals. The smaller the distance between target and film the more X-rays you have striking the film. All of these things help to determine how black the film will become. All of these things, then, have an effect on the density of the radiographic film. You want to have the proper density. You do not want your film to be too light or too dark. You want to have the right amount so you can see what you are looking for.

CONTRAST. Contrast, in X-ray, is the DIFFERENCE BETWEEN THE DENSITIES ON THE X-RAY FILM. Contrast can be understood if you will remember the other characteristics of X-ray. X-rays are absorbed in matter. This absorption depends upon the atomic structure of the matter and the wave length of the X-rays. (Figure 5-6).

30 40 50 60 KVP

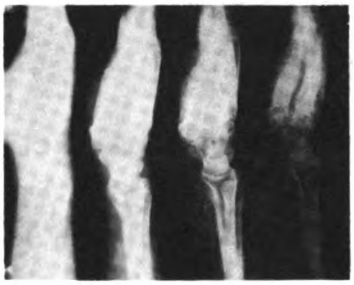


Figure 5-6 Contrast

On an X-ray film you will see variations in the degrees of blackness. Some areas will be black, others gray and others white. In the black areas a great many crystals in the film emulsion were exposed; in the gray areas not as many, and in the white areas none. The black, the gray, and the white areas "contrast" with each other. You can "see" a difference in density of the various areas.

Contrast is affected primarily by kilovoltage. Depending upon the tissue which the X-ray has to pass through, and the wave length of the X-ray which passes through it, the contrast on the film will be either high or low. The skin tissue has a relatively low atomic number so X-rays can pass through it more easily without striking any atoms in it. The thicker or heavier the tissue gets, such as muscle, the more tendency there is for X-rays to strike an atom and be absorbed. When you come to bone you have a much higher concentration of atoms which will present a greater possibility of X-rays colliding with these atoms and being absorbed. Now it is apparent that the film crystals beneath each of these types of tissue will be exposed in proportion to the amount of X-ray that can be pushed through to them. If a great number pass through, that area will be black (skin). When some of them pass through you will get a gray area (muscle). And when they are absorbed almost completely the area will be white (bone). Now the amount of kilovoltage that is applied will determine just how much penetration of each of these areas is accomplished. If a high kilovoltage is used the X-ray wave length will be shorter and will be able to squirm through the more

compact atoms in the bone. This will mean that more of them will be able to get through the atoms of the bone tissue to the crystals of the film. With a low kilovoltage the wave lengths would be longer and be absorbed more completely.

You will find that there are TWO types of contrast. One type is called SHORT SCALE CONTRAST. Short scale contrast is where the black, gray and white areas are very sharply defined. The other type of contrast is called LONG SCALE CONTRAST. Long scale contrast is where there is a blending of black, gray and white. The various areas are not sharply defined (Figure 5-7).

Long Scale Short Scale

Figure 5-7 Short and Long Scale Contrast

Contrast on an X-ray film is affected by other things besides kilovoltage, but these will be brought to your attention when you reach them in later sections.

DISTORTION. Any part of the body on a radiograph will show some degree of distortion. Distortion is the perversion of the true size and shape of a structure. In X-ray the general rule is to reduce this distortion to a minimum, but deliberate distortion is used in special types of examinations. However, for general X-ray work you will attempt to reduce distortion. If a part is completely changed in shape or if the part is magnified in size you can accept the fact that it is distorted.

Distortion is affected by four major factors. These factors are the PART-FILM DISTANCE, THE FOCAL-FILM DISTANCE, TUBE ALIGNMENT, AND FOCAL-SPOT SIZE. It is here that you must remember that "X-rays travel in straight lines and cannot be focused to a point" (Figure 5-8).

The most perpendicular rays give you the least distortion. The imaginary center ray is called the central ray.

Part-film distance is the distance between the part being examined and the film. The closer the part is placed to the film the less magnification it will have. You will be better able to produce its true size. You must realize, however, that you will NEVER be able to completely obtain its true size. Now, if you still have your flashlight turn it on and place your hand in front of it. Move your hand in front of the light toward the table and notice that as you get closer to your table your shadow reduces in size. Pull your hand back toward the light and you will see your shadow become larger.

Focal-film distance, as has been said, is the distance between the target or focal spot of the tube and the film. Focal-film distance is used to reduce distortion also. The greater the focal-film distance the less magnification you will have. You can see this also by using your flashlight. Have someone take the light and then place your hand in the beam away from the surface. Place the light thirty-six inches away from your hand. Your hand should be about six inches away from the surface the light is shining on. Notice the size of your shadow at thirty-six inches. Then have the man increase the distance to seventy-two inches and watch as he moves back how your hand shadow begins to decrease in size. This matter of focal-film distance will be very important to you in later work.

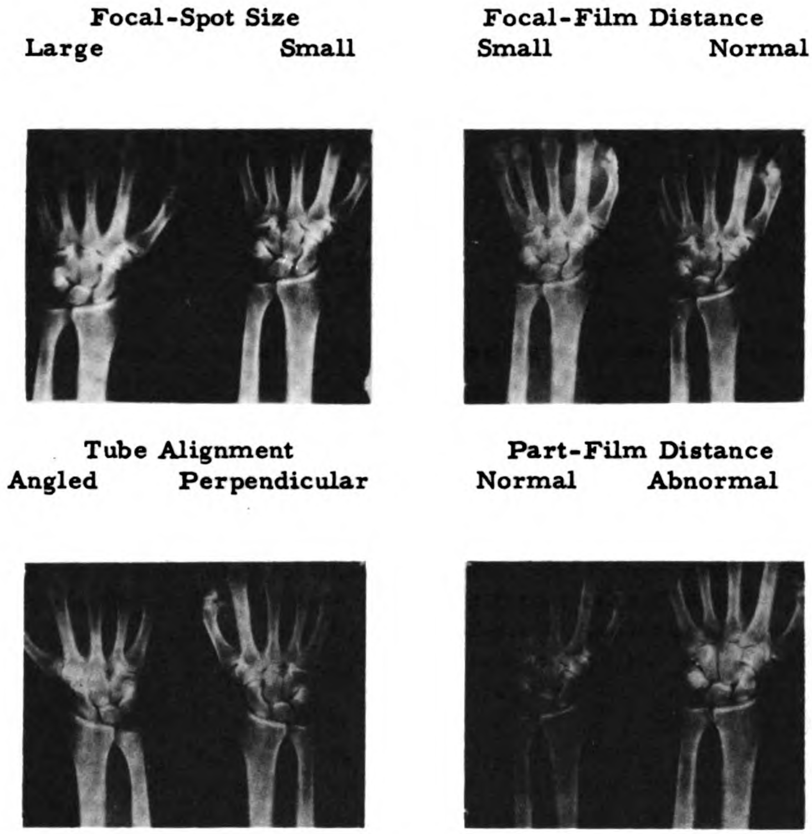



**Figure 5-8 Factors in Distortion**

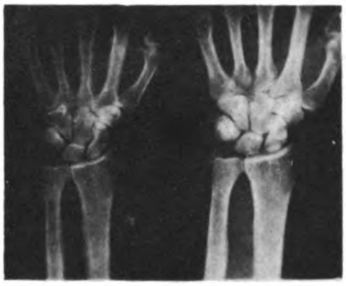
Tube alignment is another factor in distortion. In many instances we use this factor to produce deliberate distortion. However, as has been said, you will attempt to reduce distortion in routine work wherever possible. In understanding how tube-alignment affects distortion you must keep in mind the characteristic of X-ray that states "X-rays always travel in straight lines".

Focal-spot size or the size of the target in the X-ray tube also affects the amount of distortion you will have in your film. The larger your focal-spot or target is the more magnification you will see in your film. The smaller the focal-spot the less magnification you will have. In the following respect, however, X-ray and light are not comparable. The light can be produced from a pin-point source but X-ray is

produced from a much larger area. This causes the geometric pattern of X-ray to produce a fuzzier or less sharply defined image of a structure.

**DETAIL.** Detail is the degree of sharpness of the image on your film. You have seen photographs of various subjects in which the subject was hazy, as a soft tone portrait from a studio. In photography they are constantly seeking the lens which will be so sharp that it will pick up the fine whiskers on the chin of an adolescent. The same thing is true of X-ray. You attempt to provide the finest amount of line detail that you can possibly obtain. If a tiny fracture on the edge of a bone is lost because that edge was fuzzy and not well defined, that detail missed would be very important (Figure 5-9).

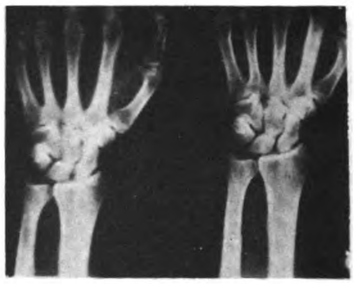
Part-Film Distance
Normal Large PFD



Focal-Film Distance
Normal Small FFD

Focal-Spot Size
Large Small

Motion Immobilized



Cardboard Cassette

Figure 5-9 Detail

Detail is affected by PART-FILM DISTANCE, FOCAL-FILM DISTANCE AND FOCAL SPOT SIZE just as in distortion, but is also affected by MOTION OF THE PART AND THE TYPE OF FILM HOLDER that is used. The first three have been explained in the discussion on distortion but will be reviewed in regard to detail.

The smaller the part-film distance the more detail you will obtain. The larger the focal-film distance the more detail you will have, and the smaller the focal spot or target the greater detail you will get. As for motion, it is both an advantage and a disadvantage. In your general X-ray work you will attempt to reduce motion of the part or patient to the minimum. Motion would cause a blur on a radiograph just like a moving truck or car would in a photograph. You will NEVER be able to completely stop motion because some of the organs of the body are in continuous motion like the heart or the digestive system. Also the condition or the age of your patient may provide you with a motion problem. Still, you must attempt to eliminate as much motion as you can in order to obtain the greatest amount of detail. The type of film holder that will help you eliminate motion will be explained to you in a very short time.

## BEHIND AND AHEAD

You have just covered some fairly technical material. It is necessary that you are aware of this information before you proceed. You know the four prime factors KVP, MA, T and D. You should understand what MAS is. You should be completely familiar with the concept of the Inverse Square Law. You should know what density, distortion, contrast and detail are and what factors affect them.

Ahead of you is information on the film used in X-ray, film holders, auxillary devices and exposure mathematics. As you study this material you will be able to grasp more fully the ideas that have just been learned. You will see how they are actually put to use.

## X-RAY FILM AND HOLDERS

X-ray film is a little different from regular photographic film. It has a base material of CELLULOSE ACETATE, but the emulsion, which suspends crystals of SILVER BROMIDE, is spread on both sides instead of only one. Modern X-ray film is called "safety" film because it will not burn rapidly as the old films used to do. Take a piece of cleared film and light one corner and watch how it burns. Then if you have a cellophane wrapper from a package of cigarettes light it and compare the two. The old film used to burn like the wrapper.

### FILM TYPES AND SPEED

In X-ray you will encounter two types of X-ray film. One is SCREEN FILM and the other is NON-SCREEN. You will be hearing about the speed of the film. The "speed" is determined by the size and number of silver bromide crystals in the emul-

sion. The non-screen film has bigger crystals and more of them. Its emulsion is thicker. It is used only when X-ray IS THE DIRECT AGENT OF EXPOSURE. It is a "faster" film and produces short scale contrast.

Screen film is used with intensifying screens which you will learn about in the next few paragraphs. It is sensitive to a BLUISH LIGHT emitted by these intensifying screens and X-RAY. It is only one-half as fast as non-screen film when exposed without intensifying screens, so it would take twice as much exposure to get the same density as a non-screen film. This is important to remember when you are using it in cardboard holders which you will also learn about in the next few paragraphs. Most of the film that you will be using in the Air Force will be of screen type.

Regardless of the type of film you use, the "speed" of the film will be a factor in your technique. Remember that the "faster" a film is the LESS exposure you need. Because of the reduction of exposure, faster and faster speed of films is being sought. The more density you can get by using less X-ray the better it is (Figure 5-10).

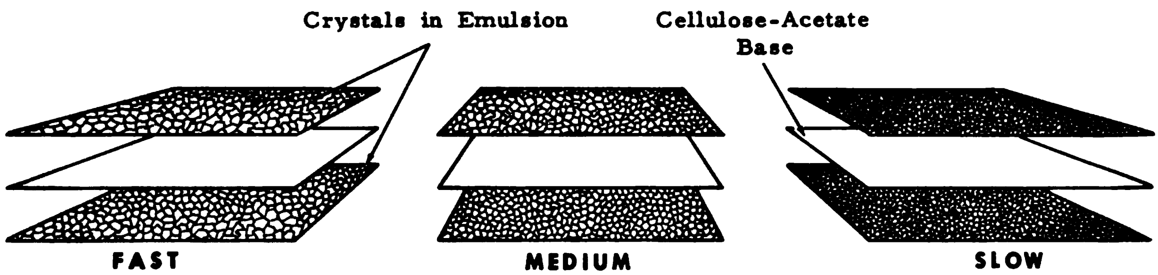



Figure 5-10 Diagram of Slow, Medium and Fast Film

You will find the following sizes of X-ray film being used in the Air Force.

14 x 17 inches

10 x 12 inches

8 x 10 inches

5 x 7 inches

Dental Film

These sizes are used in X-ray just as you have certain sizes in photography like 4 x 5, 620 or 120.

FILM HOLDERS

There are two types of film holders used in X-ray. They are the CARDBOARD HOLDER AND THE CASSETTE HOLDER.

CARDBOARD HOLDERS. The cardboard holder is made of two pieces of cardboard hinged at the top with a binding tape and fastened at the bottom with a small

metal clip. On the back piece of cardboard is a sheet of lead foil that stops stray rays. Between these sheets of cardboard a paper envelope is attached into which you place your film. The film comes wrapped in paper and the film with its paper wrapper is placed in this envelope (Figure 5-11).

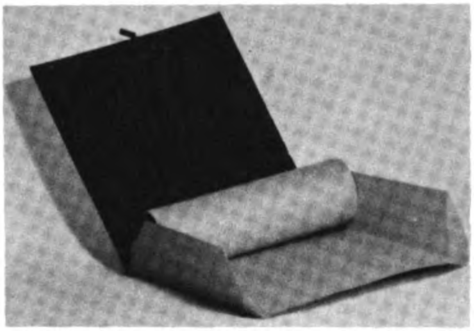


Figure 5-11 Cardboard Holder

Get a cardboard film holder from the darkroom. You will notice that marked on one side is the word "Tubeside". This is the side that must ALWAYS be placed facing the tube. Remember that the back has a lead foil sheet which stops stray rays from coming back from the table to further expose your film. Unfasten the clip at the bottom and lift the top sheet up. Inside you will see the paper envelope. You will learn how to load this holder in the chapter on darkroom procedures.

Now that you have an idea what the cardboard holder looks like, let's find out how you use it. The cardboard holder is used for parts that measure under 11 centimeters. A cardboard holder will give you better detail, but it also requires more X-ray exposure. Generally, it is used for parts like the hand or foot.

CASSETTE HOLDER. A cassette holder is a metal holder with a hinged back and a bakelite front. It is about one-half inch thick. The holder has two intensifying screens on the inside. One screen is mounted on the front and the other on the hinged back. The film is placed between these screens without the paper wrapping. The bakelite front is always placed so that it faces the tube. The X-rays pass through the bakelite easily. The screens provide a bluish light as the X-rays activate them and help to expose the film. The hinged back is made of steel, like the frame, but it stops any stray radiation that might come back from the table (Figure 5-12).

The cassette is used for all parts that measure over 11 centimeters. With its screens providing light, which helps to expose the film, the amount of exposure is about one-tenth that required when using a cardboard holder. This combination of light and X-ray exposing the film makes it a much "faster" type of exposure than just a cardboard which uses only X-ray. You will, however, lose some DETAIL because the light will blur the edges of the image.

Go to the darkroom again and get a cassette. Notice the frame and the weight. Turn it over on the bakelite surface so you can open it up. Press your fingers on either side of the hinges and turn so the back is loosened. Grasp the tab at the bottom of the back and lift up. Then notice the white screens and the film. Read on now and find out about these intensifying screens.

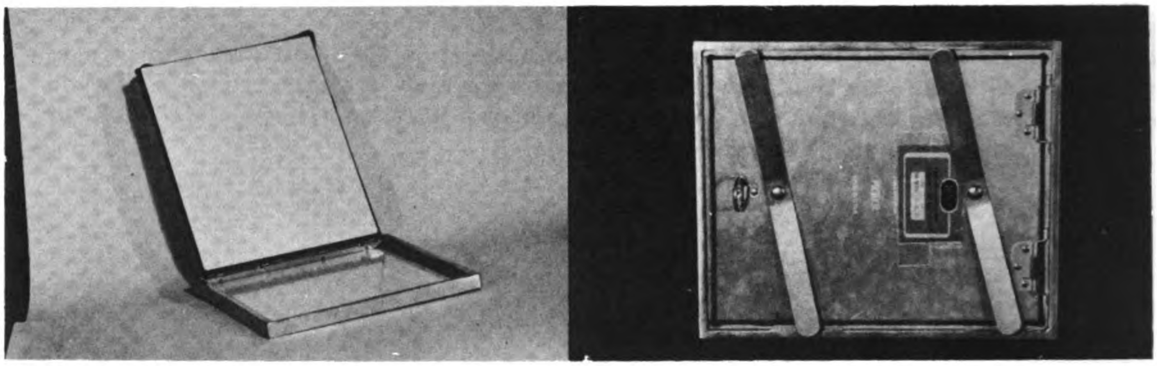


Figure 5-12 Cassette Holder

Intensifying Screens. Intensifying screens "intensify" the exposure. They are made of cardboard and covered with an emulsion that contains fine crystals of CALCIUM TUNGSTATE. These crystals, when exposed to X-rays, fluoresce or emit a bluish light. These tiny crystals spread this light in all directions and expose the silver bromide crystals in the film emulsion. These crystals will give off light according to their number and size. The bigger the crystals, and the more of them, the more light they will emit. This fact brings you to the "speed" of the screens. It is similar to the "speed" of the film (Figure 5-13).

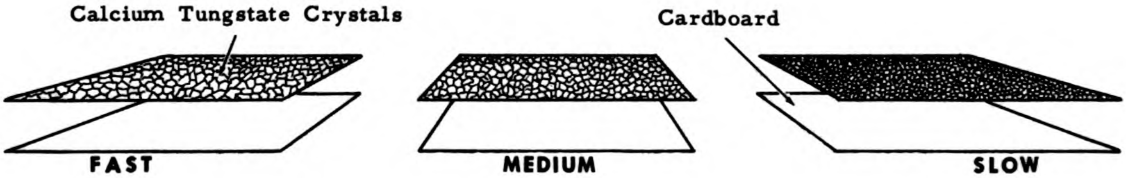



Figure 5-13 Intensifying Screens

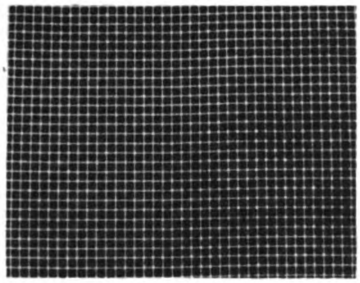
You will find that you have three types of intensifying screens. They are the SLOW, MEDIUM AND FAST screens. Usually, in the Air Force, you will use medium speed screens. The slow speed screen will have small crystals, so it will take more X-ray to get the same exposure on a film as one with large crystals. Remember that the slower the screen, the less light there is to expose the film. The use of different speed screens will depend upon the type of examinations you will be required to do.

There is one more thing to remember about screens. Although a larger crystal will give you a "faster" exposure, it will also spread out its light more and provide LESS DETAIL. The farther the light is allowed to spread out the fuzzier the image will be because more silver bromide crystals in the film are being exposed. It is for this reason that you should use the medium speed screen for most of your work. It will give you the speed necessary and at the same time more of the detail that you want.

Screen Contact. Because the light from the crystals spreads out, the film must be in very close contact with the screens. This is known as SCREEN CONTACT.

Where the film and the screens are not in close contact the light will spread out to expose more silver bromide crystals than necessary. This will cause a fuzziness in the image and reduce the detail in that area. You will learn how to care for your screens and how to check for screen contact in the chapter on the darkroom (Figure 5-14).

GOOD



POOR

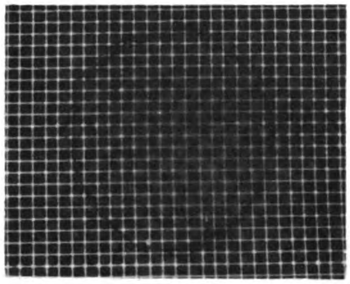


Figure 5-14 Screen Contact

## AUXILLARY RADIOGRAPHIC DEVICES

Auxillary equipment is used in radiography to improve the quality of the X-ray film, and to protect you from excessive radiation. The devices used are grids, cones, cylinders, and diaphragms and filters.

### GRIDS

Grids are used to eliminate, as much as possible, the secondary radiation that is produced from the patient and the apparatus. They are necessary for all the large body parts. There are two types of grids being used by the Air Force. These are the stationary wafer grid and the Potter-Bucky diaphragm. The Potter-Bucky diaphragm is more commonly called a "bucky".

STATIONARY WAFER GRID. This grid is a thin, rectangular device that is made in sizes to cover the different sizes of film holders. It is made up of vertical strips of lead and bakelite laid side by side. These strips are very thin and are alternated. The lead will stop X-rays and the bakelite will allow them to pass through. This type of grid has one important disadvantage. It will leave little white lines on the film where the X-rays were stopped by the lead strips. These lines are known as grid lines. The standard wafer grid has visible coarse lines. The Lysholm grid produces much finer and less noticeable lines (Figure 5-15).

POTTER-BUCKY GRID. This type of grid is a MOVING grid in contrast to the stationary grid. The Potter-Bucky type of grid moves during the exposure and blurs out the grid lines. There are two of these grids, the single motion and reciprocating grids.

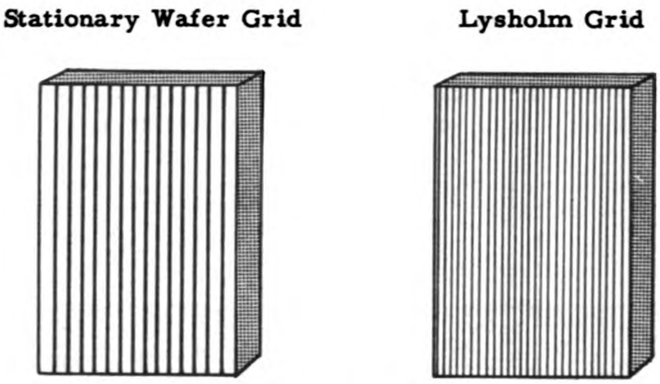



**Figure 5-15 Comparison of Grids**

If this type grid is not moved at the proper time there will still be grid lines, so it is important that the speed of the grid and the speed of the exposure be timed properly. The speed of the grid can be manually set or automatically controlled from the control panel. The Potter-Bucky grid must be in motion before the exposure starts and still in motion after the exposure stops. This way the grid will always be moving during an exposure. This motion "wipes" up most of the secondary radiation produced from the body, and blurs out the grid lines.

Grid lines can be seen in the improper use of a Potter-Bucky type of grid. Some of the common causes are:

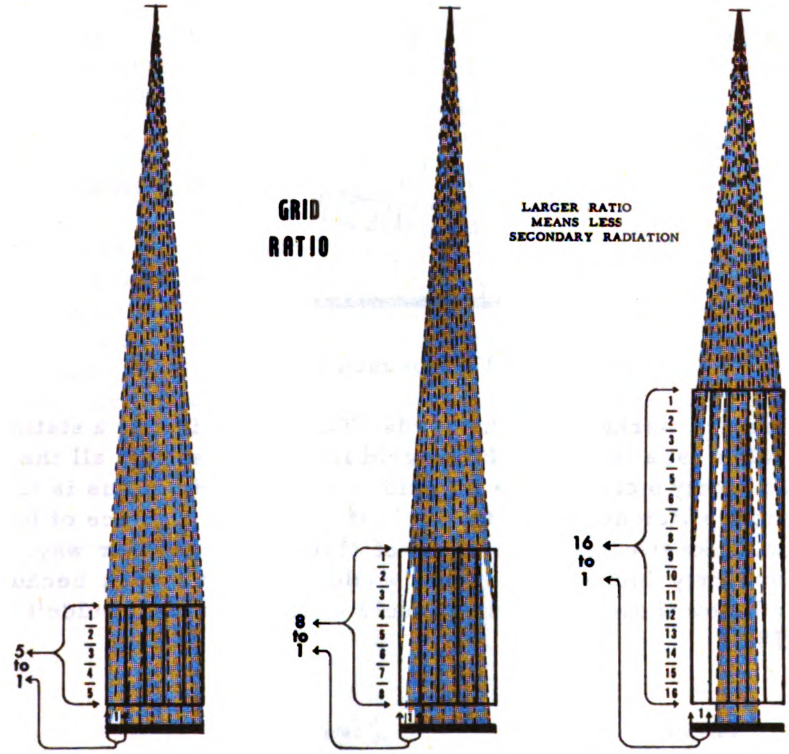
- Uneven speed of the grid. It jerks along and causes the grid to show lines.
- Exposure continued after the grid has stopped or slowed down near the end of its travel.
- Tube improperly centered. This will cause uneven density on one side of the film, and could also keep one edge of the beam continually over a lead strip and cause grid lines.
- An exposure made before the grid begins to move.

Grids that are manually set for time are of two types. These are the standard Potter-Bucky which has a time from 1/2 to 20 seconds or over, and a high speed type which can get down to 1/10 of a second. There is an automatic type called a RECIPROCATING TYPE. This is the type that will be found on many machines that you will work with. It moves back and forth during an exposure while the single motion moves across only once. The grid is automatically put into motion before your X-ray exposure is made. (When you see grid lines you usually have too fast an exposure or your tube is not centered properly.) Usually the fastest speed that you can use with a reciprocating bucky is one-tenth of a second. Times of exposure shorter than this will show some grid lines. Some improvements have been made on this matter so you may be able to use shorter times in your particular clinic.

Find out from your supervisor what types of grids you have. Take a look at them so you can see how they are made.

GRID RATIO. The amount of secondary radiation that a grid will stop depends

upon its GRID RATIO. The larger the ratio the more secondary radiation it will absorb. However, the higher the ratio, the more primary radiation you must get to the film. Grid ratio is a factor in the amount of radiation you will use. The grid ratio will determine how efficient a grid is. The grid ratio is the RATIO BETWEEN THE HEIGHT OF THE LEAD STRIP TO THE WIDTH OF THE SPACE BETWEEN THEM. You can picture this by using buildings and vacant lots. If the buildings are 100 feet high and the space or vacant lot between them is 10 feet wide then you have a ratio of 10 to 1 (10:1). You have just divided the space between the buildings into the height of the buildings. In X-ray grids you use millimeters (mm.) instead of feet, however. The common grid ratios in use today are 5:1, 8:1 and 16:1 (Figure 5-16). The 8:1 grid ratio is more commonly used now than the others.




8:1 Grid

16:1 Grid

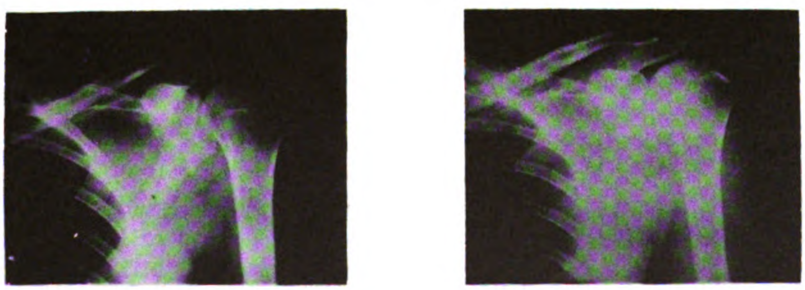


Figure 5-16 Grid Ratio

**FOCUSED GRIDS.** Most stationary grids are unfocused, but the Potter-Bucky diaphragms are of the focus type (Figure 5-17). A focused grid is a type of grid with the lead strips tilted inward slightly so that if you drew a line from the tip of each strip it would meet at a point above the grid with all the lines from the other strips. The distance between this point of intersection of all these lines and the center of the grid is the GRID RADIUS. An unfocused grid has strips that are vertical.

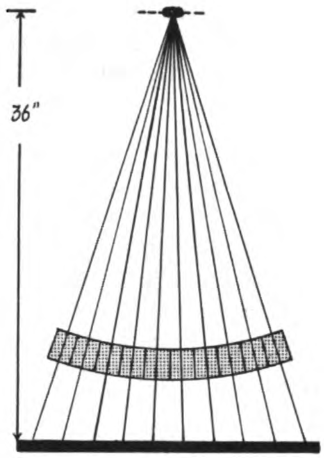



Figure 5-17 Focused Grid

Focused grids are marked with the words "Tube Side" if it is a stationary grid. This side must always face the tube. If the grid is focused so that all the strips will reach a point that is forty inches above the grid center its grid radius is forty inches. You will get the most efficiency from this grid if you use a distance of forty inches. You can, however, take twenty-five percent of this distance either way. You could use fifty inches or thirty inches, but there would be slight losses because of this. Anything above or below those two figures would show up so you wouldn't want to use them (Figure 5-18).

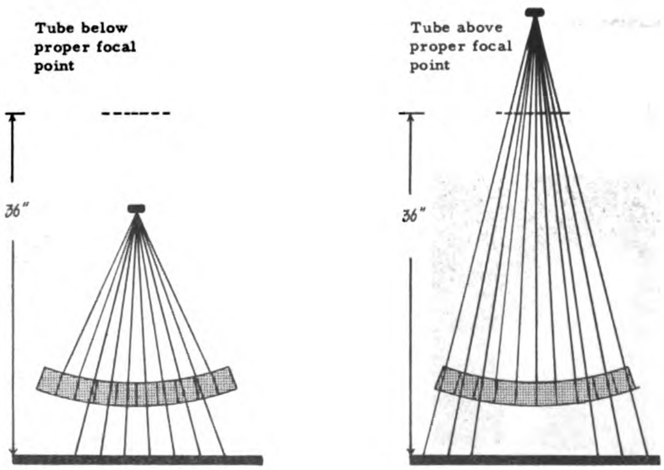



Figure 5-18 Grid Radius

USING A GRID. You will want to use a grid whenever you have a large body part to examine. Remember that you are placing lead strips between the patient and the film and that some of the X-rays that pass through the body will be absorbed in the grid. Because of this you have to increase the amount of X-ray you are using to get enough to the film. Keep in mind that the ratio of the "bucky" will also figure into the amount of increase you will need in the X-ray to be used.

When you have not been using a grid and find that one is necessary you should add three to four times the amount of X-ray you were using without it. When using a grid the general figure that is used is three and one-half (3.5) times the MAS. Thus, if your technique without a grid called for 50 MAS you would use 175 MAS with the grid. REMEMBER THIS!

You will be using a cassette with intensifying screens when using a grid. The increase of X-ray needed to get through the grid can be offset by using a cassette which requires one-tenth the X-ray that a cardboard holder does.

## CONES, CYLINDERS AND DIAPHRAGMS

Cones, cylinders, and diaphragms restrict the primary beam (Figure 5-19). This restriction decreases the amount of secondary beam by reducing the primary that reaches the film. THESE DEVICES SHOULD BE USED WHENEVER POSSIBLE. Many clinics do not apply these devices. This indicates either ignorance of their uses or laziness. As you get into the actual technique of taking a film you will learn how to use these cones, cylinders and diaphragms and the mathematics involved in their use.

Figure 5-19 Cones, Cylinders and Diaphragms

## FILTERS

Filters used in diagnostic work are thin sheets of aluminum. They are supplied in one-half and one millimeter thicknesses. The average amount of aluminum filtration used is 1.5 mm. They filter out some of the long wave lengths in the X-ray beam. This filtering action reduces the secondary radiation produced when these long rays strike the body. Because filters "harden" the beam, only the more penetrating rays reach the part.

## TECHNIQUE CHARTS

The time has come to put all the other information into focus and see just what radiographic technique is and what you have to do with it. You have now a knowledge of KVP, MA, time, distance, Inverse Square Law, density, distortion, contrast, and detail. You are aware of what cardboard, cassettes, intensifying screens, stationary and Potter-Bucky grids are. You have some background now that is necessary in using these things to begin the actual taking of a radiograph. It has not been easy to relate all of these things together. Experience is the best teacher in learning to combine all these things to produce an X-ray film. As you have probably seen by this time, there is a great quantity of variables in taking an X-ray film. If you use distance to get more detail you are forced to increase the amount of X-ray. This will cause more secondary radiation that fogs your film and creates chances for radiation injury. If you use a grid you have to increase your X-ray but you can compensate for the extra secondary radiation by using a cone and a cassette. The thing you have to do is weigh all of these factors against each other for the greatest advantage of all of them. Your prime purpose is to take a diagnostic and readable X-ray film. The choice of factors that you must choose are directed to that purpose. You must make a choice. If these choices do not give you the maximum effect you are seeking then you must revise your combinations and start all over. It is simply looking at what you have and using these for the best results. There is no reason for panic or discouragement.

### RADIOGRAPHIC TECHNIQUES

Radiographic technique is that technique of selecting the proper amount of KVP, MAS and FFD that will provide you with the best density, detail and contrast. You know that you must provide yourself and the patient with some protection from secondary radiation. To do this you will need a cone, cylinder, or diaphragm, and a grid. You must also select the proper type of film and film holder. In considering your combination of the above you must keep in mind the part of the body you are examining, the condition of that part, the age of the patient, and the purpose of the examination. But the prime thought that must lie in your mind is what the film is going to demonstrate after development. The objective of radiographic technique is to combine all of the necessary factors so that they will be revealed AFTER THREE TO FIVE MINUTES IN THE X-RAY DEVELOPER.

### TECHNIQUE OF DEVISING CHARTS

Technique charts are charts which you establish so that you can get X-rays that are the same no matter how many you take or how many different people you X-ray. These charts will tell you how much KVP, MAS and FFD you will use on every part you take. They will tell you whether to use a grid or a cassette or a cardboard. You can have these charts devised for adults and children.

There are many types of technique charts but you will learn about three or four of the more common types. Before you go on to these you will begin to build a technique chart of your own so you can see what planning is necessary in determining a good technique. Building your own chart will help you understand how to plan and change techniques.

In most techniques you will need one very important piece of equipment. This device is known as a CALIPER. The calipers measure in CENTIMETERS. All measurements of the body will be in centimeters, NOT in inches. You will use inches in determining the FOCAL-FILM distance only. There are inches on the inside of the X-ray calipers but you will not need them at this time. You will use this caliper to measure the part you are going to X-ray to see just how thick it is. Let's go on now to developing a technique chart using what you have already learned.

TECHNIQUE NUMBER ONE. You are now standing in the center of an X-ray room. In front of you is a machine with a capacity of 100 MA, 100 KV and a timer with 1/20 of a second to 15 seconds. On the MA selector you have a choice of 25 MA, 50 MA and 100 MA. You can select any of these MA that you want. You have one KV minor selector which you can turn up or down and at each click will give you an increase or decrease of 2 KVP. You also have a KV major selector which adjusts by ten's. The timer on the machine begins from 1/20 of a second and is graduated as follows: 1/20, 1/10, 3/20, 2/10, 5/20, 3/10, 4/10, 1/2, 6/10, 7/10, 8/10, 9/10, 1, 2, 3 and 4 seconds, etc. Your tube column will allow the tube to be raised until you can obtain a focal-film distance of 40 inches. You have both a cassette and a cardboard holder. You have a stationary grid on the shelf above the machine and a Potter-Bucky diaphragm under the table top. You have medium speed screens in your cassettes. The X-ray calipers are sitting on the table top of the machine and you have a cone available next to it. Do you have everything now? Machine, cassette and cardboard, stationary grid and bucky, calipers, and cone? Fine. Here comes your first patient! Do you panic? No! You see that he is to be examined for a fracture of his right hand. You look at him. He appears to be very calm and not hurting very badly. You say hello and ask him to have a seat.

And now this tells you something. He is not in great pain and seems to be steady enough so that he won't move. Looking at his hand you see through the skin and know that there is a great number of joints there. If there is a fracture in those joints you want to make sure that there is as much detail in the film as possible. These joints are small. This means that you will want to use a CARDBOARD HOLDER. What size? One that is large enough to provide space for his entire hand, of course, This will usually be an 8 x 10 or 10 x 12. Using the calipers you will place the man's hand between the movable metal piece and the base of the caliper. This will be in the area of the knuckles. You will see that his hand, if you look at the back of caliper, will measure between 3 and 4 centimeters. This would tell you again that you use a cardboard holder because the part measures UNDER 11 CENTIMETERS.

You are seeking the greatest amount of detail so you know that the greater the FFD the more detail you will have. What FFD should you use? Generally, FFD's of 30, 36, 40, 48, and 72 inches are used in most clinics. Your machine, however, will reach a vertical maximum of 40 inches. Since you know the greatest FFD will give you the most detail you make a simple decision to use 40 inches.

You have measured the hand and determined that a cardboard and a 40 inch FFD will give you maximum detail. Now, just how much KVP is necessary to travel that 40 inches and penetrate 4 centimeters of tissue and bone? Remembering that KVP is the prime factor that controls the type of contrast, you must have enough push to go through some of the bone as well as the tissue. You want to have a film that has a long scale contrast. But how do you begin to figure this KVP? YOU JUST HAVE TO MAKE A CHOICE! From experience it has been found that you will need between 40 and 55 KVP. This is a range of 15 KVP that you have to select from. You have four

choices: 40, 45, 50 and 55 KVP. You are a man of decision so you pick 50 KVP. You set your major KV selector to 50 KVP. So far your technique has developed to a cardboard holder, 40 inch FFD and 50 KVP.

You must select a milliamperage and a time setting now. How much X-ray will it take to demonstrate that hand? Here, again, experience tells you that about 100 MAS will usually give you the proper density. Density, you will remember, is the degree of blackness on the film. You decide to try 100 MAS. What MA settings are you going to use? You have three MA settings: 25 MA, 50 MA and 100 MA. You must make a choice again. It is a general rule in X-ray to make the shortest possible exposure wherever possible. This would mean that you would use the largest MA setting you have with the shortest time available which would give you 100 MAS. Your time settings are from 1/20 to 4 seconds. Now you know that MAS is the milliamperage or MA times the seconds. Would you use 25 MA times 4 seconds to get 100 MAS? No! Would you use 50 MA times 2 seconds to get 100 MAS? No! You would use 100 MA times 1 second because it would make the SHORTEST POSSIBLE EXPOSURE.

So now you have completed a technique. You are going to X-ray the man's hand using a cardboard holder, 40 inch FFD, 50 KVP, 100 MA at 1 second for 100 MAS.

You place your cone in position in the space provided for it under the tube. You place the man's hand on the cardboard holder so that both are centered directly under the tube. You see that the hand is close to the film for minimum part-film distance. You check your tube to see that it is at a distance of 40 inches. You adjust your machine controls so that the KV meter reads 50 KVP, the MA setting is on 100 MA and the timer is set for 1 second. Then you push your exposure button and make your exposure.

Looking at your film after development you see that you have detail. The edges of the bone are sharp. The cortex or the outer layer of the bone is white while the medullary canal is darker. The area of the film beyond the structure is black, the flesh surrounding the bone is varied in degrees of gray. You see no disturbing elongation or magnification. You are satisfied that you have a diagnostic film. From now on you will use the same technique for every hand that measures 3 to 4 centimeters. You make a note of this on a chart!

Hand - Cardboard - 50 KVP - 100 MA - 1 second - 40 inches - 3 to 4 cm.

What you have done is select the KVP, MAS, FFD and film holder that will give you the maximum detail, density, and contrast.

TECHNIQUE NUMBER TWO. Another patient to be examined. A fracture of the hand again, but this time your patient is in extreme pain. You must take your film faster because he cannot remain still for the period of one whole second. What are you to do? You have a good technique, but it would take too long. You will remember that if you used a cassette you could use just one-tenth (1/10) the amount you would need for a cardboard. The 40 inches FFD gave you maximum detail, the 50 KVP provided the right amount of penetration and the 100 MAS gave you good density. The right distance and the best KVP you already have, but you must reduce the time element. You do this by exchanging the cardboard holder for a cassette. If it

took 100 MAS to place a certain degree of density on the film with a cardboard holder you know that it will only take one-tenth (1/10) of that MAS to give the same density on a film in a cassette. You want to get the shortest possible exposure. You would still use 100 MA, but instead of 1 second you would use only 1/10 of a second. This would give you 10 MAS.

However, you have had to sacrifice some detail by using a cassette instead of a cardboard. This sacrifice had to be weighed against the possibility that if you used a cardboard you would need a longer time of exposure. In that time the detail could be ruined by the inability of the man to hold still. Motion would be more detrimental than using a cassette.

So you see that even when you find a good technique there will be many instances in which it will have to be changed to meet the condition of your patient. You will also see that you can develop other techniques from your basic technique.

In providing you with these two illustrations you will understand that these numbers have not just been pulled out of a hat. Each technique must be developed for each part by SOMEONE. They had to determine what holder to use, the KVP, MAS, and FFD. They had to decide if this particular part needed a grid, etc. Up to this point you have seen some of the things that you have to do in order to develop a technique. But to fully understand, let's build a technique chart with consideration of all points you have learned up to this point.

## BUILDING A TECHNIQUE CHART

The first thing you have to know is what capacity your machine has. If you only have a 100 MA, 100 KV machine with a timer that goes down to 1/20 of a second, you will not need to build a technique chart using 300 MA, 130 KV and time down to 1/60 of a second. On every machine there is a chart which is known as the TUBE RATING CHART. This chart is in graph form and will show the MAXIMUM amount of energy you can impress on your tube without damaging it (Figure 5-20).

Notice that it has the KVP listed up the left side, the time listed across the bottom and the MA curving through the vertical and horizontal lines. This graph will tell you just how long you will be able to use a certain MA setting. For example, if you were going to use 70 KVP at 100 MA you would follow the line from 70 KVP across the chart until it met the line marked 100 MA. At this point you would look down the vertical line to find out just how much time you could impress 100 MA at 70 KVP across that tube. You will find that you can operate it for 9 seconds. You will be able to get 900 MAS in one continuous exposure if you wanted to. But you will never need to push your machine to its maximum. It would be like driving your Cadillac at 240 horsepower all the time. It would wear out just as fast as one with less horsepower. Because it works under its maximum rating most of the time it will last longer and when it is necessary to use peak capacity it will be there. Never operate your machine beyond its capacity.

You will also notice that the chart is marked "Full Wave Rectified Equipment". If you had some malfunction that produced only half-wave rectification you would be able to use only one-half of the capacity. You will find charts for full rectification,

half-wave rectification, and self-rectification.

When you are thoroughly familiar with the capacity of your machine you will then have to review the various areas of the body. You will need different techniques for specific areas, age, purposes and conditions.

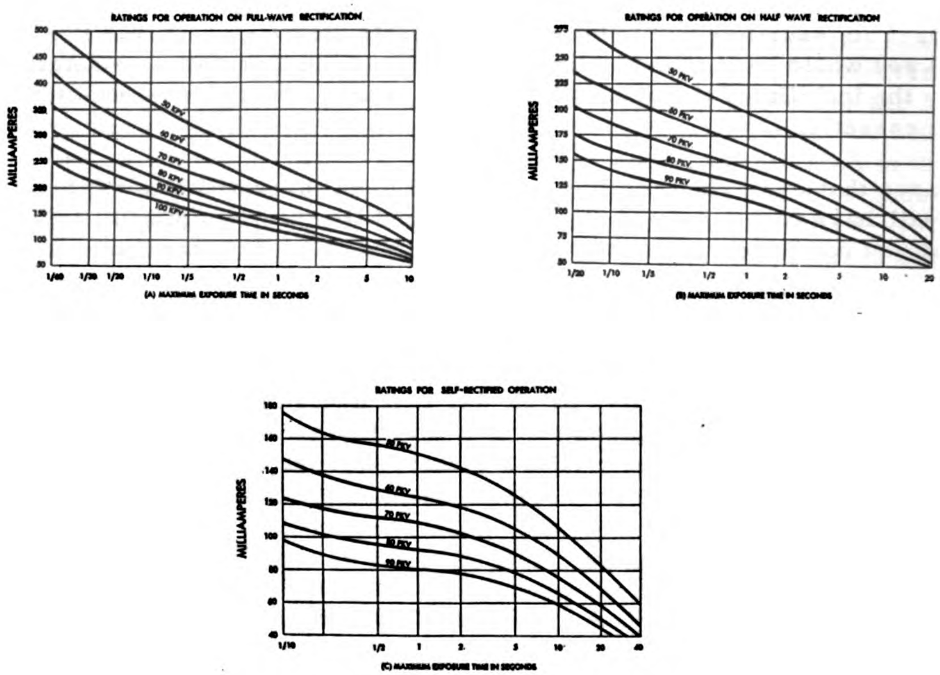



Figure 5-20 Tube Rating Chart

## SMALL PARTS - UPPER AND LOWER EXTREMITIES

Look at your body now. You can see that from your hand to the humerus the thickness is generally under 11 centimeters. This fact will tell you that you could use a cardboard holder and that a grid would not be a great necessity. You will find, however, that the tissue becomes thicker the farther up the extremity you go. This will tell you that you will need a difference in KVP for the different parts. It has been shown that the MAS required for these parts can be approximately the same. You also know that the greatest FFD is an advantage in producing detail.

Since KVP is the only factor which will be required to change for each part, you can set the other factors down as the same for all parts.

| | | | | | | |
|---|---|---|---|---|---|---|
| Hand | Cardboard | No Bucky | 40" FFD | 100 MA | 1 Sec | 100 MAS |
| Thumb | " | " | " | " | " | " |
| Wrist | " | " | " | " | " | " |
| Forearm | " | " | " | " | " | " |
| Humerus | " | " | " | " | " | " |

Now you must experiment with the KVP. It has generally been accepted that for every centimeter of tissue you will require an additional two KVP. But you have to find that KVP which will give you adequate penetration of the thinnest part. In this section of the body you will start with the hand. You find out that for a three centimeter hand, measured across the knuckles, it will take 48 KVP to penetrate it. This KVP will give you good contrast. From this, then you will begin to build your KVP.

| CM Thickness | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|
| KVP | 48 | 50 | 52 | 54 | 56 | 58 | 60 | 62 | 64 |

You now have completed basic technique. On these parts and parts similar to them, like the foot and the ankle, you can look at your chart and take your X-ray. One thing to remember, however, is that there are different positions of the same part taken in radiology which will require you to measure thickness for every position. Your wrist can be used for an example. In the antero-posterior position it will measure, say, 5 centimeters. In the lateral position it will measure 7 centimeters. As you see it will take more KVP to penetrate it in the lateral position than it will in the antero-posterior.

So now that you have more complete information, let's put it all together and see what the chart from this section of your body looks like.

| PART | POSITION | MAS | MA | SEC | DIST | BUCKY | REMARKS |
|---|---|---|---|---|---|---|---|
| Hand | Pa-Obl | 100 | 100 | 1 | 40 | No | Cardboard |
| Thumb | Ap-Lat | 100 | 100 | 1 | 40 | No | Cardboard |
| Wrist | Pa-Lat | 100 | 100 | 1 | 40 | No | Cardboard |
| Forearm | Ap-Lat | 100 | 100 | 1 | 40 | No | Cardboard |
| Elbow | Ap-Lat | 100 | 100 | 1 | 40 | No | Cardboard |
| Humerus | Ap-Lat | 100 | 100 | 1 | 40 | No | Cardboard |

| CM Thickness | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|
| KVP | 48 | 50 | 52 | 54 | 56 | 58 | 60 | 62 | 64 |

If you have a man coming in for a routine examination of the wrist you can look at your chart and see that you will be using the PA and LAT positions. You will set your machine for 100 MAS by setting your MA selector to 100 and your timer to 1 second. You will use an FFD of 40 inches. You will not use a grid. And you will use a cardboard holder. You will measure your patient's wrist in the PA position and find that it measures 5 cm. For 5 cm. you will use 52 KVP. You will measure his wrist in the lateral position and find that the wrist measures 7 cm. You will use 56 KVP for the lateral position.

Now, if you will look over the chart above, you will see that there is a great amount of repetition. All of these parts are using the same MAS, MA, seconds, distance, no bucky and a cardboard holder. You will notice, too, that most all of the parts will be under eleven centimeters. If you did this for every part you would have a chart that would be plastered all over the clinic. It would take time to hunt out each individual part and its technique. You can abbreviate this chart to save time and effort in locating these techniques.

You realize that the hand, thumb, wrist, forearm, elbow, humerus, foot, ankle and leg will generally measure under 11 centimeters and that you will use a cardboard holder to examine them. Here you could bunch all of these separate parts into one heading like "SMALL PARTS - CARDBOARD". These nine separate parts and the technique for them would look like this:

Small Parts - Cardboard - (All Parts under 11 Centimeters)

| POSITION | MAS | MA | SEC | DIST | REMARKS |
|---|---|---|---|---|---|
| Ap, Pa, Lat | 100 | 100 | 1 | 40 | When using cassette use 100 MA at 1/10 sec. |

| CM Thickness | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|
| KVP | 48 | 50 | 52 | 54 | 56 | 58 | 60 | 62 | 64 |

You may know by this time that this would be basic and that you may find many instances in which you must reduce the time or wish to reduce the amount of exposure. It has been illustrated that this can be done by using the cassette instead of the cardboard. You could place this information in the "Remarks" section.

## SHOULDER AND PELVIC GIRDLE

Now that you have some concept of how to make a chart let's look at some other body areas that need special techniques. The shoulder joint, scapula, clavicle, knee, lower two-thirds of the femur, hip joint, and pelvic bones present characteristic features which will cause you to select cassettes and grids. They are either surrounded by a great mass of flesh or they are areas of compact bone. In either case, these structures create extensive secondary radiation. Even within these areas you will find the need for variation of MAS values. You cannot readily combine them into one block but you can reduce your chart material by combining the areas which are alike. These parts will range from approximately 12 to 20 centimeters in thickness. There will be a wide range of tissue density which will require higher KVP's than in the extremities.

The scapula, shoulder joint, clavicle, knee and lower femur are placed in a group by themselves. They will usually measure between 12 and 20 centimeters. These areas will use a cassette and a grid. You must consider the effect the addition of these two devices have on your technique. What is the grid ratio? What is the grid radius if it is a focused grid? What speed intensifying screens do you have in the cassettes?

To establish a beginning point you will assume that you have the more commonly used grid and intensifying screen. This will be a 36-inch Potter-Bucky diaphragm and medium speed screens. You will also be using medium speed film. Knowing that you are going to use a bucky and cassette you can make the following classification: Small parts - cassette with bucky.

You will also know that you will get maximum efficiency at 36 inches because you have a bucky with a grid radius of 36 inches. You will use a 36 inches FFD. You must now find a MAS and a KVP which will give you good density and contrast. It has been found that 25 MAS will give you the density you want.

Let's see now what your chart is beginning to look like.

Small Parts - Cassette with Bucky

| POSITION | MAS | MA | SEC | DIST | REMARKS |
|---|---|---|---|---|---|
| Ap, Pa, Lat. | 25 | 100 | 5/20 | 36 | |

You know that the parts of the shoulder and pelvic girdle are thicker. They have more muscular tissue and compact bone than the extremities. This will mean that you must have more penetrating X-rays to get through to the film. You will need a higher KVP than in the extremity area.

You must experiment to get your proper KVP. You are seeking the proper amount of penetration that will give you the most desirable contrast. You pick an area like the shoulder joint, measure it and see that it is 15 centimeters thick. You do not attempt to keep on the same KVP scale as the lower extremity scale because you know there is a difference in tissue and that you have added a grid and a cassette. You have also reduced your distance from 40 inches down to 36 inches. But you do have the idea that the KVP will be a bit higher, even though the distance is less. So you try to strike a happy medium. You try exposures at 60 KVP, 65 KVP and 70 KVP. You see that the film that had 65 KVP is the one that looks the best to you. This means that 65 KVP should be used for parts measuring 15 centimeters in the shoulder and pelvic girdle. Your chart will show the centimeter thickness and kilovolts as illustrated below.

| CM Thickness | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|
| KVP | 61 | 63 | 65 | 67 | 69 | 71 | 73 | 75 |

You haven't forgotten about the pelvic girdle and the amount of MAS it will require. You find that 25 MAS is not giving you the proper density that you are seeking. You raise it, say, to 30, then 40, and finally 50. Fifty looks the best for the antero-posterior pelvis and the antero-posterior and lateral hip, but it is just not enough to show the pelvis in a lateral position. You must have another MAS value for that one position alone. One other thing about the lateral pelvis is that you are usually going to measure KVP right past the KVP capacity of the machine. If your measurement calls for 110 KVP when you only have 100 you will never be able to do it. You can

make up for that lack of KVP by using more MAS. In a certain amount of MAS, like 50, you will only have so many short wave lengths that will get through a large thickness. However, if you created more X-rays you would be able to produce that many more short wave lengths and although most of them are being stopped you would still get more of them through the part. So the lateral pelvis is a type of area where the capacity of your machine will not allow you to use KVP to push through, so you have to use more MAS to make up for it. There are other ways to meet this problem but you will learn those later.

Once you have reached the limit of your machine in KVP you must use more MAS. You find out that it will take the 200 MAS to give you a density you like. Your chart for this area would look like the illustration below.

Small Parts - Cassette with Bucky

| PART | POSITION | MAS | MA | SEC | DIST |
|---|---|---|---|---|---|
| Shoulder, clavicle, scapula, knee, lower 2/3's of femur | AP-PA Lat | 25 | 100 | 5/20 | 36 |
| Pelvis | AP | 50 | 100 | 1/2 | 36 |
| | Lat | 200 | 100 | 2 | 36 |
| Hip Joint | AP-Lat | 50 | 100 | 1/2 | 36 |

| CM Thickness | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| KVP | 61 | 63 | 65 | 67 | 69 | 71 | 72 | 73 | 75 | 77 | 79 | 81 | 83 | 85 |

There are also body areas like the skull and the chest which have peculiar characteristics that require separate techniques.

SKULL TECHNIQUES

In the skull you have a particular shape and concentration of bone. The roundness of the skull causes an image of it to be unavoidably distorted. It is also in this area that you become aware of the importance of close part-film distance. In the skull the side which is away from the film is blurred out and only that area closest to the film is shown on the film. The structures within this round skull also present difficulties. Because one structure is always overlapping others, it is necessary to use a great deal of angulation, which produces deliberate distortion, to throw one structure away from the others. The skull will also create a great deal of secondary radiation and because the head is more susceptible to radiation injury, exposure must be limited. The skull is examined by the use of many special positions and will be an area that will have individual techniques.

In determining techniques to be used in the skull, you see that you need a grid and screens. A maximum FFD is needed also because the tiny structures within the skull must have maximum detail. You will need higher KVP for the skull so you can

reduce the amount of MAS. A higher KVP is also needed when you introduce angulation because layers of bone will be superimposed over each other. You will need a variation of technique because you have the differences of tissue of the various structures. For example, the sinuses are delicately constructed and contain air. You don't want to over-expose this area. On the other hand, the petrous pyramids are made of a dense concentration of bone which will require heavier exposures.

To develop techniques for the skull will take time and experience and a thorough concept of density, detail and contrast. You must also be fully aware of the anatomy of the skull and the relationship of its structures to each other.

Before you can fully grasp the concept of necessity of special techniques for specific areas of the skull, it is important that you develop a basic skull technique. From this basic technique you can create modifications that will provide you with suitable techniques for special view or conditions.

You have found out that you need maximum distance, a grid and a cassette. You also know that you want the least amount of MAS possible and that you need more KVP. The skull is an area that is susceptible to minor motion and because detail is so essential your exposure time must be the smallest you can make it.

Where do you start? The normal skull will usually measure from 18 to 21 centimeters from front to back. Laterally, from side to side, it will measure from 13 to 16 centimeters. The routine positions to show the entire skull are antero-posterior, postero-anterior and the lateral views. It has been shown that 40 MAS will give you approximately the proper density. Let's set it down and see what you have.

Skull - Cassette with Bucky

| POSITION | MAS | MA | SEC | DIST | REMARKS |
|---|---|---|---|---|---|
| AP-PA<br>Lat | 40 | 100 | 4/10 | 36 | |

Your KVP is found by experiment. You have found that at 16 centimeters 66 KVP gave you adequate penetration. The KVP factor would then appear as illustrated below.

| CM Thickness | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| KVP | 60 | 62 | 64 | 66 | 68 | 70 | 72 | 74 | 76 | 78 | 80 |

From this basic technique, then, you could develop techniques for the paranasal sinuses, mastoids, petrous pyramids, facial bones, etc. In doing this you must keep in mind that some of the areas are dense bone like the petrous pyramids and others are thin wafer-type bones like some of the facial bones. You also must consider that the sinuses contain air which offer little resistance to passing X-rays. You must keep in mind that angulation of the tube will throw various bones over each other and thus add to the density of the part you are going to have to penetrate.

## CHEST TECHNIQUES

The area of the chest is peculiar in that it is a great air-containing structure. Because air is not much of a barrier to X-ray, the area of the chest will need considerably less exposure to obtain good density than other body areas. Also because of the great amount of air present in the chest region, the amount of secondary radiation that is produced in this area will not detract from the film if proper techniques are employed. However, the use of a grid is warranted in many instances. You will also find that cassettes are used for examination of the chest.

The two main factors which influence a technique for the chest are detail and reduction of magnification. In the examination of the chest you will, whenever possible, use an FFD of 72 inches. This is the optimum distance that you can use and this distance reduces the structures to their more normal size. This is important both for lung studies and for examination of the heart. Distances of 36 or 30 inches will magnify the chest structures to a detrimental point and preclude any accurate diagnosis. As with every statement in X-ray there will be some instances when these smaller distances will be used, but on general chest work the greater distance is employed.

You will find that the most commonly used MAS in chest work is 10 MAS. This is used with the routine postero-anterior position. Up to 25 centimeters a grid is not used, but 25 centimeters and beyond will require one. You are then obligated to increase your MAS factor to compensate for the addition of the grid. This grid is usually of the stationary wafer type. There are many examinations of the chest which require additional positions, such as the lateral and obliques which cause you to change your MAS factor. The KVP used for the PA position will be used for the lateral and oblique positions as well. The MAS must be increased for each position. This area would be something like that of the lateral pelvis. Your caliper would show greater measurement than you could obtain from the KVP capacity of your machine.

## CERVICAL TECHNIQUES

The cervical spine area is another spot where a distance of 72" is necessary. This is specifically for the lateral view of the cervical spine. Because the seventh cervical lies within the region of the shoulder, the neck cannot be placed directly against the film. There will be a great part-film distance from your neck to the film because of the shoulder. As you remember you can obtain greater detail with a larger focal-film distance, so if you cannot get minimum part-film distance you can compensate with a maximum focal-film distance. This will reduce the magnification to proper limits. There are times, however, when this magnification is desired, but in routine work it must be reduced.

This 72" distance is provided when you turn your tube so that it is parallel to the floor and your rays are traveling horizontally instead of vertically.

So now you have some idea as to where all those numbers are arrived at on the charts you have been seeing. You must realize that you will use some charts that are already prepared. However, you must realize also that there will be changes needed from these various techniques when you go to another machine or to another station. NO TWO X-RAY MACHINES WILL OPERATE IN THE SAME IDENTICAL MANNER. On one machine you may be using a technique of 100 MA and 70 KVP and

getting a good film. On another machine you will find this technique too heavy or dark. You will have to change your technique to fit the machine. Even two machines in the same clinic will not give you identical densities. There will be a difference between portable and fixed machines as well. Some machines will have more capacity than others and you will have to develop techniques for them all.

## AGE FACTOR IN TECHNIQUES

The age of the patient is a factor in determining techniques. An infant from 1 day to 2 years will require about 70% less milliamperage than the adult, and children from 6 to 10 years about 50% less than the adult. This will be the approximate reduction with the exception of the chest. The density of the lung tissue of the child is greater overall than the adult chest. As the child grows older this density will decrease. If you have a basic adult technique you can devise an infant and children technique. You must remember that many of the bones have not formed yet and that the structures are still cartilaginous in form. You must also keep in mind that children will be most generally uncooperative and that the shortest possible exposure should be used in your techniques. For successful child radiography you will need at least one-tenth second on your timer. This does not mean that you cannot make satisfactory examinations, but without fast timers and higher capacity machines your success will be limited.

The elderly adult will also affect your techniques. With age the bones are not as well calcified and the tissue becomes less dense. You will find that you will be required to reduced your techniques to match these decreases in tissue density. You will also find that the smallest time possible should be employed. Elderly people, especially when ill, are prone to produce motion when being examined.

## PATHOLOGY FACTOR IN TECHNIQUES

Disease will cause you to modify your basic techniques. If there is added growth or increased fluid in a structure caused by pathology, you will need to increase your techniques. When there is erosion or a degeneration of tissue then the techniques will have to be reduced. Certain types of diseases are capable of producing both a decreased density of tissue and as they begin to heal, an increased density. In examining these various cases of pathology it is well to ask your doctor if it is in a degenerative or an additive condition so you can adjust your technique to suit it.

## TREATMENT DEVICE FACTOR IN TECHNIQUES

Various kinds of treatment devices will affect your techniques. Plaster casts on broken bones will cause you to change your techniques. If the cast is wet it will require more MAS than when it is dry. Bandages and dressings also present problems when they cannot be removed.

## TYPES OF TECHNIQUE CHARTS

The types of technique charts used today in the Air Force are the TISSUE THICKNESS, PLUS FACTOR, BODY TYPE, AND HIGH KILOVOLTAGE TECHNIQUES. The

tissue thickness is the most common and the easiest to understand. This is used to obtain consistency in examinations.

TISSUE THICKNESS. The tissue thickness type of chart is the type that you have just been building. This chart is prepared on the assumption that once sufficient penetration is obtained from KVP, the MAS factor can remain the same. Thus, if you use 50 MAS for a part, this MAS will give you the required density even though the thickness of this part will vary from person to person. It is the KVP that is used for the increase or decrease in thickness (Figure 5-21).

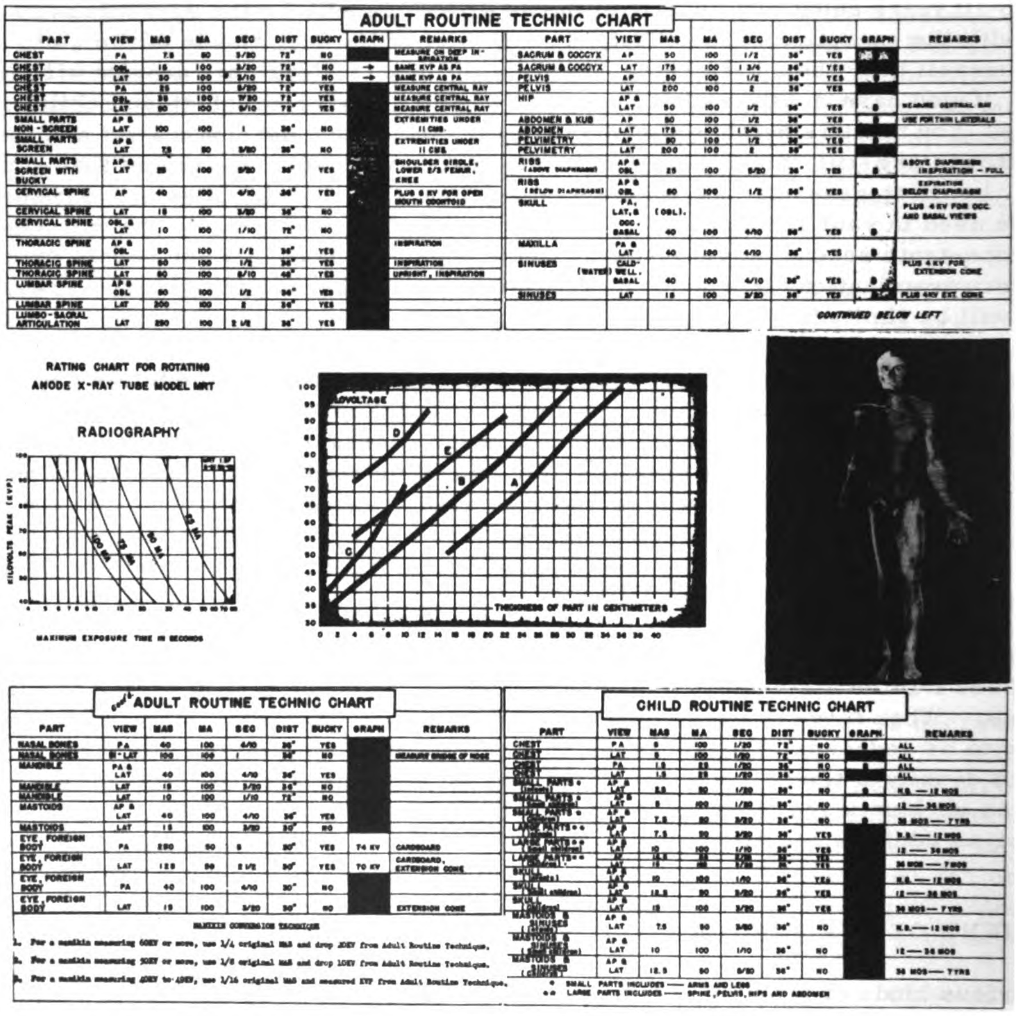



Figure 5-21 Tissue Thickness Chart

PLUS FACTOR. The plus factor type of technique is another technique that requires measuring of the part with X-ray calipers. In this technique you must keep in mind the various types of tissue density in the body. The bones of the knee would be more dense than those of the ribs, etc. From these general concepts of tissue density you must select a base KVP. This base KVP is one which will penetrate a given area on an average patient. After this has been determined you measure the

part and multiply the centimeter thickness by two (2) and add this to the base KVP. Thus, if you had a knee with a base KVP of 40 and measured the part at 13 centimeters your technique would be as illustrated below.

Knee - Cassette - 40 MAS -- 40 plus (13 x 2) equal 66 KVP -- 36 FFD - Grid

Your MAS and FFD would have to be figured from the capacity of your machine as with other charts. This type of chart is used extensively with field equipment when you have no technical factors available from an organized and proven chart.

BODY TYPE. The body type of technique is based on the assumption that a certain amount of KVP is necessary to penetrate, but that the various types of body habitus or build will require varying amounts of MAS. For instance, if you have a certain kilovoltage thickness relationship such as you have seen in the tissue thickness and plus factor techniques, the MAS factor would be determined by the type of body you are X-raying. The body types are average, large, and small. This type of technique assumes that a certain amount of KVP and MAS can be used for the average individual, but that increased or decreased MAS is required for large or small individuals. Thus, you could have a technique as illustrated below.

Abdomen - 68 KVP - 36 FFD - Cassette - Grid

| | | |
|---|---|---|
| Large A | A | 100 MAS |
| Average B | B | 75 MAS |
| Small C | C | 50 MAS |

This type of chart is also known as the OPTIMUM KILOVOLTAGE TECHNIQUE. This technique will have the same KVP, but will vary its MAS. The same KVP does not apply to all body parts, but just those parts or areas which exhibit the same type of tissue density.

HIGH KILOVOLTAGE. The high kilovoltage type of technique is a technique that is dependent on high kilovoltages and low MAS. The higher the KVP the more penetrating the wave length. This fact will allow you to use a great deal less X-ray. This technique will show an overall gray contrast film, but the tissue outline can be seen more easily. You will need a high ratio grid such as the 16:1, as the higher a KVP is the more secondary radiation you will produce.

You will see in some instances various charts which have more than one choice of KVP range. This chart is used to vary the type of contrast you are required to show. Remember that the KVP will determine the type of contrast that is demonstrated on your film.

Now that you are familiar with the various types of technique charts that you may encounter, and you know how a technique is built, you must learn some of the ways in which these basic techniques are changed to meet various conditions. You will constantly be required to modify these basic techniques. As you have read there

is an age factor, treatment device factors, pathology and injury factors which must be included in your final techniques.

Many other factors will be involved in your final techniques such as machine limitations, malfunctions, auxillary equipment limitations, etc. The next section is one that will provide you with ways to modify these basic techniques to suit these varying conditions.

## EXPOSURE MATHEMATICS

If you know how to divide one dollar into four quarters, or know that a dime is one-tenth of a dollar, you know some mathematics. You need have no fear of the simple mathematics you will find in your X-ray work. It is necessary at times, so you must learn those basic principles of X-ray exposure mathematics. It is assumed that you have been instructed in the basic addition, subtraction, multiplication and division of numbers.

Now where do you use arithmetic in X-ray? You will sometimes encounter the task of performing an examination on a portable machine. You will be required to convert the technique of your fixed, high capacity equipment to a technique that is within the rating of a low capacity machine. For example, let us say you have been using a 100 MA and 100 KVP machine. Your technique calls for 100 MA, 1 second and 70 KVP. Your distance has been 40 inches. Your portable machine has only 30 MA and 85 KVP capacity. Your problem is to determine a technique that will provide you with the same density using the portable equipment that you got using the fixed equipment.

In X-ray you have a formula that has been devised that will allow you to make this conversion. It is known as the PHOTOGRAPHIC EFFECT FORMULA. It is written:

$$\text{PE equals } \frac{\text{MA} \times \text{T} \times \text{KV}^2}{\text{D}^2}$$

As you see you have division, multiplication, fractions, proportions, powers, square roots, algebraic equations, and possible decimals to work with in this formula.

Now don't allow yourself to begin skipping. You will review the basic principles of fractions, proportions, ratios, powers, square root and algebraic equations. If you have not had this type of mathematics you will find that they can be easily learned.

### FRACTIONS

Fractions are a part of a whole number. The whole number 1 can be divided into fractions, such as 1/2 or 1/4. The top number of the fraction is the NUMERATOR, and the bottom number is the DENOMINATOR. In the fraction 3/8 for example, the number 3 is the numerator and 8 is the denominator. Notice that the numerator 3 is a smaller number than the denominator 8. When the numerator is smaller than the denominator, the fraction is a PROPER FRACTION. If the numerator is larger than

the denominator, as 8/3, the fraction is an IMPROPER FRACTION.

Fractions are reduced to smallest possible numbers by dividing the fraction with a common denominator. For example, the proper fraction 4/8 can be reduced by dividing both numerator (4) and denominator (8) with the number 4, which will reduce the fraction to its lowest terms.

$$4/8 \div 4/4 = 1/2$$

The improper fraction 9/4 is reduced in a similar manner.

$$9/4 \div 4/4 = 2\text{-}1/4$$

With improper fractions, you divide both numerator and denominator by the denominator. In the above example, you divided by the denominator 4.

In X-ray you will be working with time exposures measured in fractions of seconds. For example, with a technique that calls for a time of 10/20 of a second at 100 MA, you should first reduce the 10/20 second to its lowest terms.

$$10/20 \div 10/10 = 1/2$$

Your time for this technique, therefore, is 1/2 second at 100 MA.

In the addition of fractions, if the denominators are the same, you add the numerators and place them over the denominator.

$$1/7 + 2/7 + 3/7 = 6/7$$

If the denominators are unlike, you must divide the denominator of each fraction into a common denominator and multiply the numerator with the result.

$$2/5 + 3/4$$

The smallest number into which both denominators, 5 and 4, can be divided is the common denominator 20. The fraction 2/5 is equal to 8/20, and the fraction 3/4 is equal to 15/20.

$$8/20 + 15/20 = 23/20$$

$$23/20 = 1\text{-}3/20$$

In the subtraction of fractions, if the denominators are the same, you subtract the numerators and place the result over the denominator.

$$6/9 - 4/9 = 3/9$$

$$3/9 = 1/3$$

If the denominators are unlike, find the smallest number into which both denominators can be divided, as you did in the addition above.

$$3/4 - 2/5$$

The smallest number into which both denominators, 4 and 5, can be divided is 20. The fraction 3/4 is equal to 15/20, and the fraction 2/5 is equal to 8/20.

$$15/20 - 8/20 = 7/20$$

In multiplying fractions, multiply the numerators and the denominators.

$$3/4 \times 2/5 \times 1/3 = 6/60$$

reduce 6/60 to 1/10

To divide fractions, you must invert the divisor, and multiply. The divisor is the number you want to divide into another number. The number being divided is called the dividend. For example, divide 7/8 (the dividend) by 4/10 (the divisor).

$7/8 \div 4/10$ Invert the divisor (4/10)

$7/8 \times 10/4 = 70/32$

reduce $70/32 = 2\text{-}6/32 = 2\text{-}3/16$

## PER CENT AND DECIMALS

Fractions can be expressed in other terms. These terms are per cent or decimals.

A per cent is a fraction that is some part of 100. It has the sign %. An example of per cent is 43%. This means that it is 43 parts of 100. So 43% is equal to 43/100. You will not be able to use per cent in figuring your arithmetic. You have to reduce a per cent to a fraction or a decimal.

A decimal is a proper fraction that is 10 or some power of ten. A power of 10 can be illustrated in this manner. Ten is the first power, ($10^1$). 10 x 10 equals 100 so this is 10 to the second power ($10^2$). 10 x 10 x 10 is 1000 so this is 10 to the third power ($10^3$), etc. As long as you keep multiplying you will be raising the power of ten. 10 x 10 equals 100. 100 x 10 equals 1000. Powers are written with a superscript such as $10^1$, $10^2$, $10^3$.

Now decimals are the fractions of this 10 or power of 10. Anything below 10 such as 9 would be a fraction of 10. In decimals this is designated with the point (.) sign. The fraction 9/10 as a decimal would look like this (.9).

Decimals are read in tenths, hundredths, thousandths, ten-thousandths, etc.

### COMPARISON

| Per Cent | Decimal | Fraction |
|---|---|---|
| 10 % | .1 | 1/10 |

## TABLE OF DECIMALS

| | |
|---|---|
| .1 equals one-tenth | $10^{-1}$ |
| .01 equals one-hundredth | $10^{-2}$ |
| .001 equals one-thousandth | $10^{-3}$ |
| .0001 equals one-ten thousandth | $10^{-4}$ |

The addition and subtraction of decimals require that the decimal points be placed directly under each other.

Addition

```
  2.786
  4.1
  8.05
 ------
 14.936
```

Subtraction

```
 7.8743
 2.057
 ------
 5.8173
```

Multiplying decimals is done just as if you were using whole numbers. After you have gotten the product you start from the right side and count off toward the left the number of decimal points used in the problem. There must be the same number of decimal places in the product as there are in the figures you are multiplying.

```
  72.1                    Your answer = 15141     727.3334
   2.1                    Two points                   2.2
  ----                    from right  = 151.41    --------
  72 1                                            14546668    Five decimal
 1442                                            14546668     points to right
 -----                                           ---------
 1514 1     Product                              160013348 =  1600.13348
```

When dividing a whole number into a decimal, you place the decimal point in the quotient directly above the decimal point in the dividend.

```
         Quotient            202.0
Divisor | Dividend        15 | 3030.0
```

## RATIOS AND PROPORTIONS

Ratios are relationships between two numbers. These numbers are called TERMS. The ratio is found by dividing the first term into the second term. If you have an X-ray tube that costs $2400 and another which costs $800 you can find the ratio by dividing the terms. 2400:800 = 3:1. The cost of the more expensive tube is three times the cost of the less expensive tube. Or you could have the opposite ratio. 800:2400 = 1:3. This says that the less expensive tube costs only 1/3 the money that the more expensive tube costs.

Proportion is an expression of equality between TWO ratios. The expression 8:4 = 12:6 forms a proportion. All proportions must be composed of two equal ratios as illustrated below.

$$8:4::12:6 = 8/4 = 12/6 = 2:1::2:1$$

The same ratio is there, no matter how big the number.

In proportions, 8:4::12:6, the two outside terms, 8 and 6 are called the EXTREMES. The two inside terms, 4 and 12 are called the MEANS. Since the ratios are always equal in any proportion you will find that multiplying the extremes together and the means together, the products of each will be the same.

Multiply the extremes $8 \times 6 = 48$

Multiply the means $4 \times 12 = 48$

So far you have known all four numbers in your proportion. But what if you didn't have one of them? How would you find it? As long as you know three of the terms you can always find the fourth.

The use of proportions in X-ray is a very common occurrence. You will use it for finding relationships between the factors, KVP, MAS and FFD. Let's see how this works.

You have a technique that calls for 100 MAS and 36 inches FFD. The spring breaks on your tube column and you cannot get above 30 inches FFD. What new MAS would you have to use to get the same density you had using 100 MAS? Remember that you are closer to the film and that if you used the same amount of MAS your film would be darker. You want the same density so you must have less MAS.

Now let's look at this problem. You have to find your ratios. You know the first ratio, 100 MAS:36" FFD equals a certain density. The other is an "unknown MAS":30" FFD. This new ratio has to equal in density the first ratio. The two densities are the proportions of darkness and are the equals, just like 48 was the equal of the previous example. Setting the ratios down you can see how they resemble the previous problem. But let's use "X" for the unknown MAS. Also you must remember to put things that are alike together.

$MAS_1 : MAS_2 :: D_1^2 : D_2^2$

100 MAS:"X" MAS::$36''^2$ : $30''^2$

100 MAS:"X" MAS::1296 :900

Remember the Square:
$36 \times 36 = 1296$
$30 \times 30 = 900$

Now multiply the extremes: $100 \times 900 = 90,000$

Multiply the means: $X \times 1296 = 1296X$

$$1296X = 90,000$$

$$90,000 \div 1296 = 70 \text{ and } 1160/1296$$

Forget the fraction and you have 70 MAS as the new MAS you will need at 30 inches to get the same density on the film that you got with 100 MAS at 36 inches.

You should be familiar with proportions from the beginning of this chapter. Direct proportion is when you have the first MAS, then the second MAS, the first FFD and then the second FFD. In the inverse proportion the formula would have the second FFD before the first FFD.

$MA_1 : MA_2 :: D_1 : D_2$ is a direct proportion

$MA_1 : MA_2 :: D_2 : D_1$ is an inverse proportion

Remember that these are just examples. You will receive the proper formulas later.

ALGEBRAIC EQUATIONS

You had a formula given to you at the beginning of this section. This formula is an algebraic equation. You have used letters instead of numbers. Algebra helps us to find unknown numbers. In the above formula you see TWO sides.

$$PE = \frac{MA \times T \times KV^2}{D^2}$$

Left side of equation    Right side of equation

Now Photographic Effect is the radiographic density or blackness on the film caused by so much KVP, MA, T and D. You are going to find out what the Photographic Effect is when you use 30 MA, 2 seconds, and 50 KVP at 30 inches FFD. Look at the left side of your formula and you see PE. On the right side of your formula you see:

$$\frac{30 \times 2 \times 50^2}{30^2}$$

$$PE = \frac{30 \times 2 \times 50^2}{30^2}$$

PE= 30 x 2 = 60. 60 x $50^2$ (Squared 50:50 x 50 = 2500) = 60 x 2500 = 150,000. 150,000 is placed on the right side as the numerator. Now the distance is squared. 30 x 30 = 900. This 900 becomes the denominator.

$$PE = \frac{150,000}{900}$$

Divide 900 into 150,000 and you find that PE = 166 (Approximately).

$$166 = \frac{30 \times 2 \times 50^2}{30^2}$$

You know now that the photographic effect on that film is 166 when using the technique that was shown. But just what does this 166 mean? It has been said that it is the density. If you just take a film with a certain amount of blackness on it and say that this film has a photographic effect of 1, the 166 just means that it is 166 times as black as the 1.

You are still interested in how algebra is going to be used. You have found that the PE was 166 with the technique used. Now what if you wished to increase the distance to 40 inches FFD and still retain a PE of 166? You can use the algebraic equa-

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You are still interested in how algebra is going to be used. You have found that the PE was 166 with the technique used. Now what if you wished to increase the distance to 40 inches FFD and still retain a PE of 166? You can use the algebraic equa-

tion to help you. You now have a new distance so because it is greater you know that the film will be lighter if you use the same MA, T, and KVP. You are going to have to find a new MA or T or KVP to keep a PE of 166. You decide to use more MA. You have been using 30 MA up till now. What new MA can you use along with the other factors and still keep a PE of 166? Your formula would change slightly because you are no longer looking for PE but for MA.

$$166 = \frac{\text{"X"} \times 2 \times 50^2}{40^2}$$ set down numbers in place of letters

$$166 = \frac{X \times 2 \times 2500}{1600}$$ square numbers requiring squaring

$$166 = \frac{5000X}{1600}$$ divide denominators into numerator

$$166 = 3X$$

$$3X = 166$$ reverse sides and divide 3 into 166.

$$X = 53 \text{ MA approximately}$$

But what happens if you do not have a 53 MA machine? What if you only have 50 MA as a choice? - you choose 50, of course.

## SQUARE ROOT

In some types of problems you will have to find the square root of a number. You know that a square of a number is determined by multiplying a number times itself. 30 x 30 = 900. Now if you just had the number 900 how could you find the number that when it is multiplied by itself will give you 900? This is known as trying to find the square root of a number. The symbol is "$\sqrt{\quad}$". Do not be surprised if all numbers do not come out even. There will be close approximations which will be sufficient for your work.

To find the square root of 900, first separate the numbers into groups of two figures each, starting at the decimal point (in this instance the decimal point is 900.0) and forming the groups, first to the left and then to the right of the decimal point. If there is an odd number to the left of the decimal point, there will be one group containing a single number. However, if there is an odd number to the right of the decimal point, add a zero so that each group contains two figures. Then find the largest square which can be subtracted from the first group on the left.

$\sqrt{900.00}$ Place the sign and number down.

$\sqrt{9.00.00}$ Mark off your places on either side of the decimal point. You have one odd number on the left.

Find the largest square which can be subtracted from the first group at the left. You will notice that 3 x 3 = 9 so that 3 is the largest square that can go into 9. Write

it underneath the first group.

$$\begin{array}{l} \phantom{\sqrt{}}3 \\ \sqrt{9.00.00} \\ \underline{9\phantom{00}} \end{array}$$

$3 \times 3 = 9$. Write the square root of this largest square above the first group as the first figure of the square root. Subtract the square number from the first group. Bring the next group down to go with a remainder.

$$\begin{array}{l} \phantom{\sqrt{}}3 \\ \sqrt{9.00.00} \\ \underline{9\phantom{00}} \\ 0\ 00 \end{array}$$

Now you have to form a trial divisor. You do this by multiplying the root already found by 2 and annexing a zero. With 3 being the first figure it will become 6 + a zero to become 60.

$$\begin{array}{l} \phantom{\sqrt{}}3 \\ \sqrt{9.00.00} \\ 9 \end{array}$$

Divide the remainder (0 00) by the trial divisor (60). 60 won't go into 0 00 so the 0 is placed next to the 3 in the quotient. In cases where the number could be 1 or 6, etc. you would add it to the divisor (61, 66, etc.)

You now multiply the complete new divisor by the new figure of the root which is 0. $0 \times 60 = 0$. Subtract the product from the remainder. Continue to bring down the other groups if you have them until all are used or the desired number of decimal points have been reached. Since each figure of the root is placed directly above its corresponding numbers or groups, the decimal point in the root is placed directly over the decimal point in the given number.

$$\begin{array}{l} \phantom{\sqrt{}}3\ \ 0.\ 0 \\ \sqrt{9.00.00} \end{array}$$

Check your answer by squaring it. $30 \times 30 = 900$. So 30 is the square root of 900.

You have now had a brief review of the basic mathematics that you will use in X-ray. The following section is a composite of the various formulas and how they are used in solving problems.

## FORMULAS AND SOLUTIONS

You can use these formulas and follow the steps in their solutions for a great many of your practical problems. It is good to try and memorize as many of these formulas as you possibly can. The more important ones will be placed at the begining. Those which you will be called upon to use less frequently will be placed at the end.

### HOW TO CHANGE MA OR DISTANCE

MA-Distance Rule: THE MA IS DIRECTLY PROPORTIONAL TO THE SQUARE OF THE DISTANCE.

$$MA_1 : MA_2 :: D_1^2 : D_2^2$$

Example: In a given technique, a proper radiographic density is obtained with 40 MA at a distance of 48 inches FFD. What must the MA be in order that the same radiographic density at a distance of 72 inches FFD may be obtained?

$$MA_1 : MA_2 :: D_1^2 : D_2^2$$

$$40 : \quad X :: 48^2 : 72^2$$

$$40 : X :: 2304 : 5184$$

$$2304\ X = 207,360$$

$$X = 90 = \text{NEW or 2nd MA}$$

HOW TO CHANGE MAS OR DISTANCE

MAS-Distance Rule: The MAS is DIRECTLY PROPORTIONAL TO THE SQUARE OF THE DISTANCE. (As you see it is the same formula with the seconds added to it.)

$$MAS_1 : MAS_2 :: D_1^2 : D_2^2$$

You can use the same numbers as in the previous example, but the 90 would be MAS instead of just MA.

HOW TO CHANGE TIME OR DISTANCE

Time-Distance Rule: THE TIME OF EXPOSURE IS DIRECTLY PROPORTIONAL to the SQUARE OF THE DISTANCE.

$$T_1 : T_2 :: D_1^2 : D_2^2$$

This formula is used when time alone is the thing you want to change. For instance you may want to use this when you have one timer which will only go down to 1/10 of a second and you exchange this timer for one which goes down to 1/60.

As you see all of these formulas are DIRECTLY PROPORTIONAL TO THE SQUARE OF THE DISTANCE.

HOW TO CHANGE MA OR TIME

MA-Time Rule: THE MA VARIES <u>INVERSELY</u> TO THE TIME OF EXPOSURE.

$$MA_1 : MA_2 :: T_2 : T_1$$

(Notice in inverse formulas you place the second time ahead of the first time).

Example: In a technique with 65 KVP, 100 MA, 0.9 seconds and 30 inches FFD, a proper radiographic density is obtained. If the MA is changed to 60 MA, what should be the exposure time in order to get the same radiographic density? Remember that in an inverse problem one factor has to go up and the other down. In this case you will have to increase your time to maintain the same density.

$$MA_1 : MA_2 :: T_2 : T_1$$

$$100 : 60 :: X : .9$$

$$60\,X = 90$$

$$X = 1.5 \text{ seconds (new or 2nd time)}$$

Remember that MA x T = MAS. 100 x .9 = 90 MAS

60 x 1.5 = 90 MAS

## HOW TO CHANGE KVP AND DISTANCE

KVP-Distance Rule: THE SQUARE OF THE KVP VARIES DIRECTLY AS THE SQUARE OF THE DISTANCE.

$$KVP_1^2 : KVP_2^2 :: D_1^2 : D_2^2$$

Example: In a technique, 60 KVP, 60 MA, 3.5 seconds and 30 inches FFD you obtain poor detail. You want to increase your distance to 48 inches FFD for more definition. What new KVP is needed so the film will have the same density?

$$KVP_1^2 : KVP_2^2 :: D_1^2 : D_2^2$$

$$60^2 : X^2 :: 30^2 : 48^2$$

$$3600 : X^2 :: 900 : 2304$$

$$900X^2 = 8{,}294{,}400$$

$$X^2 = 9216 \text{ (Find square root)}$$

$$X = 96 \text{ (New or second KVP)}$$

## HOW TO CHANGE KVP AND MAS

KVP-MAS Table: There is no definite mathematical relationship when there is a requirement for changing KVP and MAS. There is a table that has been devised that will give you satisfactory results. This table is used for fast modifications required when you run into KVP, or MAS limitations on your machines. It is an inverse type of table, however. If you raise your KVP you must reduce your MAS.

$$MA_1 : MA_2 :: D_1^2 : D_2^2$$

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$$MA_1 : MA_2 :: T_2 : T_1$$

$$100 : 60 :: X : .9$$

$$60X = 90$$

$X = 1.5$ seconds (new or 2nd time)

Remember that MA x T = MAS. 100 x .9 = 90 MAS

60 x 1.5 = 90 MAS

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**KVP-MAS TABLE**

| INCREASE | DECREASE | DECREASE | INCREASE |
|---|---|---|---|
| 10 KVP | MAS to 1/2 original | 10 KVP | Double MAS |
| 15 KVP | MAS to 1/4 original | 15 KVP | Four times MAS |
| 28 KVP | MAS to 1/10 original | 28 KVP | Ten times MAS |

An example: If you were using a technique from your chart of 60 KVP and 50 MAS and you wanted to reduce the amount of exposure you were giving to a particular part, you could raise the KVP to 70 and use only 25 MAS, to 75 KVP and use only 6.5 MAS or to 88 KVP and use only 2.5 MAS. Which would be better - the 50 MAS or the 2.5 MAS?

## HOW TO DETERMINE THE SIZE OF CONE FIELDS

A cone is identified by the diameter of its opening and the length of the cone. There are many sizes of cones. You use cones to restrict the primary beam to the smallest possible area. If you need to restrict the beam to one particular size of film you must be able to figure how big a cone field is necessary to cover that size of film. As you have read, you will be using film of 8 x 10 inches, 10 x 12 inches and 14 x 17 inches. These are rectangular in shape and you must find a circle large enough to completely cover them.

To do this you must find the FILM DIAGONAL or the length from one corner of the film to the other (Figure 5-22).

RULE: THE FILM DIAGONAL SQUARED IS EQUAL TO THE FILM WIDTH SQUARED PLUS THE FILM LENGTH SQUARED.

$$D^2 = W^2 + L^2$$

Example: $X^2 = 8^2 + 10^2$

$X^2 = 64 + 100$

$X^2 = 164$ (Find square root)

$X = 12.8$ inches (Film diagonal)

Film diagonals: 8 x 10 = 12.8 inches

10 x 12 = 15.6 inches

14 x 17 = 22 inches

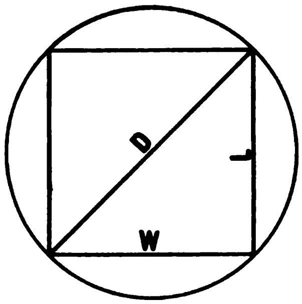



Figure 5-22 Film Diagonal

## CONE FIELD FORMULA

Now that you can find the diagonal of a film you will next have to create a ci-cle approximately 13 inches, 16 inches and 22 inches depending upon the size of film you are using. You have a formula which you will use to determine this circle. You have four factors in this formula.

- Focal-Film Distance (FFD) Distance from focal spot to film.
- Anode-Lip Distance (ALD) Distance from the focal spot to the bottom of the cone itself.
- Diameter of Cone Field (DCF) Distance across center of your circle.
- Diameter of Cone (DC) Distance across center of your cone opening at the bottom of your cone.

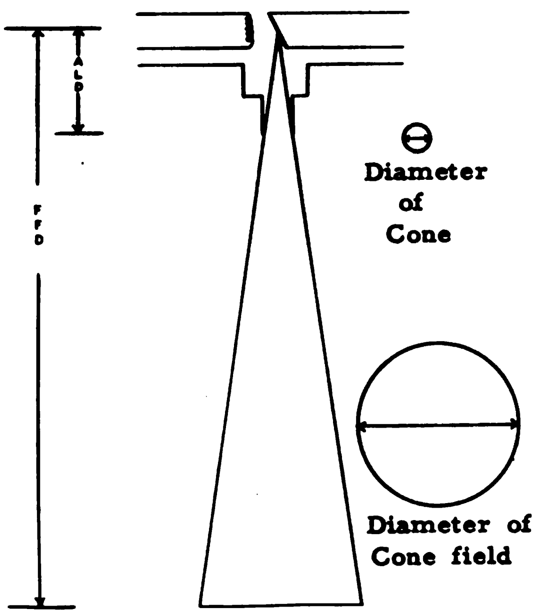



Figure 5-23 Cone Field

You will need to know three of these factors to find the fourth.

Example: If you have a focal-film distance of 40 inches, an anode-lip distance of 20 inches, and are using a cone which has a diameter of 8 inches, what size cone field would be produced?

FFD : ALD :: DCF : DC

40 : 20 :: x : 8

20X = 320

X = 16 inches (Size of cone field)

Now what if you knew that you were going to need a 16 inch cone field but were using a different distance, or you had a different size diameter cone or you had to use a smaller length of cone? You could find any of these factors by substituting "x" in the proper place and figure as above.

In many instances you are interested in getting a cone field that is much smaller than the film itself. You do this when you radiograph the gallbladder or some of the small structures of the skull such as sinuses, sella turcica or mastoids.

Example: You want to have a 6-inch cone field on your film. You are using a cylinder cone so that you can vary your anode lip distance. The cone has a diameter of 4 inches. You are using a FFD of 36 inches. You have to find the anode-lip distance which will give you a 6-inch cone field.

FFD : ALD :: DCF : DC

36 : x :: 6 : 4

6 x = 144

x = 24 inches anode-lip distance

But what if your cylinder cone will not extend to 24 inches? What if you can only get an anode lip distance of 18 inches? The only thing left is to get a new distance.

FFD : ALD :: DCF : DC

X : 18 :: 6 : 4

4 X = 108

X = 27 inches (New FFD)

When using a diaphragm, which is a sheet of lead with a hole cut in it, you have a little more figuring to do. The size of the field on the film is primarily determined by the size of the hole in the diaphragm (Figure 5-24). The diaphragm is placed in the slot used for the filter in the port of the X-ray tube. You will have four factors again.

- **Focal-Film Distance (FFD)**
- **Anode-Diaphragm Distance (ADD) Distance between target and opening of diaphragm.**
- **Diameter of Diaphragm Opening (DD)**
- **Diameter of Projected Circle or Field (DPC)**

**FFD : ADD :: DPC : DD**

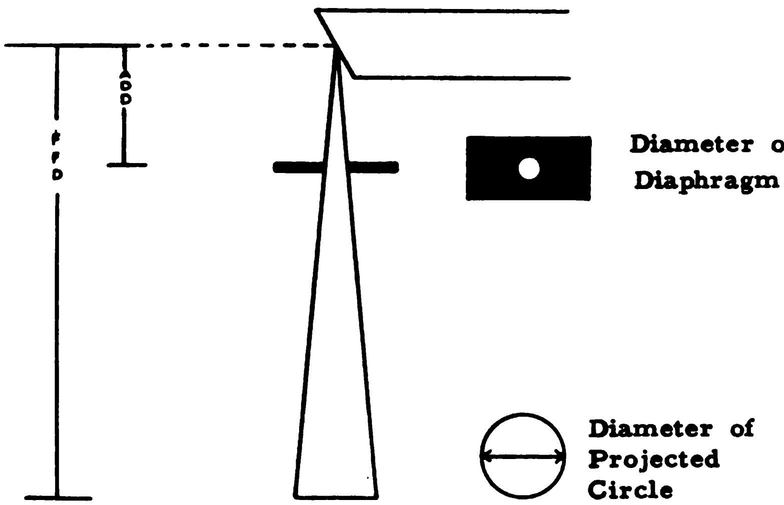



**Figure 5-24 Diaphragm Factors**

**For example: You are using an FFD of 36 inches. You have an Anode-Diaphragm Distance of 3 inches. You want to project a circular field of 10 inches. What must the diameter of the diaphragm opening be?**

**FFD : ADD :: DPC : DD**

**36 : 3 :: 10 : X**

**36 X = 30**

**X = .8 inch (Diameter of opening)**

**What size of a projected circle would you get if you used this .8 inches diameter diaphragm at 30 inches FFD?**

**FFD : ADD :: DPC : DD**

**30 : 3 :: X : .8**

**3 X = 24**

**X = 8 inches (Diameter of Projected Circle)**

The difficulty with diaphragms is usually that the Anode-Diaphragm Distance is not known and it is difficult to get an accurate measurement of it. There is a means of finding this distance. If you have a certain diameter of diaphragm you can find the ADD. The formula is ADD equals $\frac{\text{FFD X DD.}}{\text{DPC}}$ You have to take an experimental film. Just place a film under the tube and place your diaphragm in the opening. Make an exposure. From the exposure you can determine the ADD.

For example: You have a diaphragm with an opening of 1 inch diameter. You are using 36 inches and you have measured the projected circle on the film to be 10 inches.

$$\text{ADD} = \frac{36 \text{ X } 1}{10}$$

$$\text{ADD} = \frac{36}{10}$$

$$\text{ADD} = 3.6 \text{ inches}$$

From then on you will know that your ADD will be 3.6 inches.

A cone, diaphragm or cylinder will reduce the intensity of your beam. When using one of these devices you must make a compensation in one of your KVP or MAS factors if the technique was originally devised without a cone. Generally, you will compensate by adding 3 to 10 KVP or increasing your exposure time 15 to 50 per cent. Experience will be your guide when selecting the proper compensation.

COMPENSATION TECHNIQUES FOR VARIOUS DEVICES

Many techniques are developed that must be compensated when a treatment device or an auxillary device is added to the exposure. Unless proper addition or subtraction of factors such as KVP or MAS are made, the radiographic quality of your film will be reduced.

PLASTER CASTS. One of the most common treatment devices you will meet are casts of plaster used to immobilize fractures. The amount of penetration or X-ray needed to get through these casts will be determined by the dryness or wetness of the cast. A new wet cast will take more X-ray than a cast that has been allowed to dry out.

Wet Cast (One to two days) 3 X MAS or add 12 KVP

Dry Cast (Over two days old) 2 X MAS or add 6-8 KVP

WHEN CHANGING SPEED OF SCREENS. There may be some instances when the use of a fast or a slow speed intensifying screen would provide the quality of film you need. If your technique has been devised for a par speed (medium speed) screen you would have to make an adjustment in your exposure.

**Changing from Medium to High Speed Screens**

**Decrease MAS by 25%**

**Changing from Medium to Slow Speed Screens**

**Increase MAS by 60%**

If you had a technique developed for a medium speed screen of 60 MAS you would use only 45 MAS when using a high speed screen, or 96 MAS when using a slow speed screen.

GRIDS. If you happen to be using a technique that was developed without using a grid, you will have to increase your technique when a grid is added. When you have a grid technique and you change the ratio of the grid to a higher ratio you must increase your technique.

Adding a grid to a non-grid technique - 3.5 X MAS

Removing a grid from a grid technique - 1/3 of MAS

When adding grids compensate by ratio:

5:1 - 3 X MAS or add 10 KVP

8:1 - 3.5 X MAS or add 15 KVP

16:1 - 5 X MAS or add 25 KVP

FROM ADULT TO CHILD TECHNIQUE. The amount of MAS needed by children is less than the adult. This amount is related to the age of the child and, of course, to the condition from which the child is suffering. Below is a table for routine exposures.

Birth to 2 years - 70% less than adult MAS

Three to five years - 60% less than adult MAS

Six to ten years - 50% less than adult MAS

## HOW TO DETERMINE THE HEAT STORAGE CAPACITY OF A TUBE

As you know, approximately 99.8% of the energy expended in the tube is turned into heat. This heat can build up in the tube until it reaches a maximum. The amount of heat that is produced is determined by the number of exposures made and the factors used in making these exposures.

The unit is HEAT UNITS. It is found by multiplying KVP X MA X Sec. If you were using 50 KVP, 100 MA and 1 second you would figure as follows:

KVP X MA X Sec

50 X 100 X 1

5,000 H. U.

You will find on your tube rating chart the maximum number of heat units you can put on the tube. You could put this maximum number of heat units on the tube in one exposure or a number of exposures. There is also a cooling chart on your tube rating chart. This chart will tell you how long it will take for your tube to cool (Figure 5-25). This information is necessary to you if you have a large number of people to X-ray at one time. The capacity of the tube for heat units will determine just how many people you can X-ray in one minute or one hour without hurting the tube.

Now if you had a tube that could store 72,000 H. U. using full wave rectification and you were producing 5,000 H. U. per exposure, how many exposures could you take?

$$\frac{\text{Maximum Heat Unit Capacity}}{\text{H. U. Per Exposure}}$$

$$\frac{72,000}{5,000} = 14.4 \text{ exposures}$$

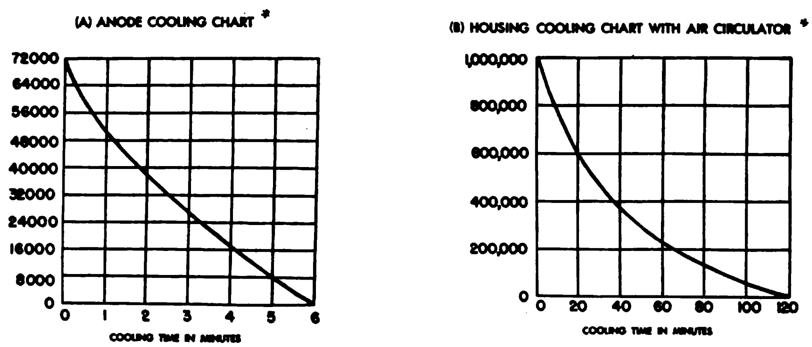



Figure 5-25 Heating and Cooling Capacity Tube Rating Chart

You can make 14.4 exposures one right after the other without exceeding the safety of the tube. Now even as you are producing these H. U. you will find that there is a cooling rate to consider. If you reached your maximum heat capacity of 72,000 H. U., how long would it be before you could expose again? Let's say that the tube cools at 25,000 heat units per minute. You would find how long it would take by dividing the cooling rate into the amount of heat units produced.

$$\frac{\text{Heat Units Produced}}{\text{Cooling Rate}}$$

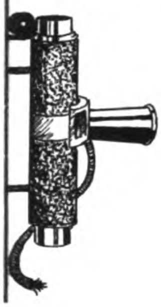
$$\frac{72,000}{25,000} = 2.88 \text{ minutes}$$

You would not have to wait the full 2.88 minutes because as soon as you had reduced your maximum heat units by 5,000, you could make another exposure of 5,000. Generally you will not be using exposures so close together that you need worry about this, but it is necessary to know. You will find this necessary more in working with photofluorography which you will find out about later.

## BEHIND AND AHEAD

You have now completed most of the essentials of radiographic technique. You should be able to formulate a variety of techniques and be able to compensate for many variations in those techniques. You should know the mathematics you will be using. The information in this chapter will expand for you as you obtain practical experience on the job. You must use your eyes to observe your films. Compare your films with each other and strive constantly to improve your knowledge of radiographic technique.

Ahead of you is a chapter which is concerned with radiographic positioning. Just as a model poses in certain positions for photographs, you will be required to position your patient for specific views of anatomy. It is an important chapter for you. Together with radiographic technique, it will give you the "core" of X-ray.



# CHAPTER 6

## RADIOGRAPHIC POSITIONING

Radiographic positioning is a very important part of your X-ray knowledge. It is the technique of placing the parts of the body in certain positions so the various structures of those parts can be seen on a film. A model used by a photographer is positioned or posed to bring out certain attributes. The same thing is done by the X-ray technician. He poses his patient in various positions to get the picture of disease or fractures in his patient's body.

Positioning requires the technician to place the part to be examined so that X-rays pass through it and expose the film which is beneath it. Because you are positioning the body to show organs or structures inside the body you will use a number of different positions. There are many structures in the body that cover up other structures. To get to these covered structures, you have to take side views or angle either the patient or your X-ray tube. In this chapter you will learn how to position the body for viewing a great number of its internal structures.

### BASIC POSITIONING KNOWLEDGE

### PRINCIPLE OF TUBE-PART-FILM ALIGNMENT

The main principle of positioning concerns tube-part-film alignment. This is the placing of the tube, part and film so that they are lined up. You cannot take an X-ray of a part if you do not have the X-rays passing through it. You cannot take an X-ray if you do not have the film under the part.

| RIGHT | WRONG | WRONG | WRONG |
|---|---|---|---|
| Tube | Tube | Tube | Tube |
| Part | Part | Part | Part |
| Film | Film | Film | Film |

## THE CENTRAL RAY

The central ray is that ray which is coming straight down from the center of the tube. As you know the X-ray beam sprays out. (Each ray diverges slightly as the rays spread out to the edge of the beam). In positioning you are attempting to keep the part from becoming distorted and you MUST realize that the most perpendicular ray should ALWAYS be centered to the part being X-rayed. This means that you must position the tube as well as the part.

## PART-FILM DISTANCE

You are aware of the necessity for minimum part-film distance. It is the distance between the part and the X-ray film holder. In radiographic positioning you attempt to have the part as close to the film as possible. Keeping the distance between the part being X-rayed and the film to a minimum is important. Sometimes this requires that you build your film up to the part or readjust your technique to compensate for it by increasing your FFD.

## REDUCING MOTION

Motion is detrimental to detail. It will make the image obtained fuzzy. In positioning you must find means of reducing motion to a minimum. Many of the positions you will see later are difficult for a normal person to maintain. When your patient is sick, weak, or injured, it is even more difficult to maintain the position. There are many mechanical means of reducing motion such as sandbags, restraining bands, pillows, rolled sheets or towels, head clamps and stoppage of breathing during exposures. Reducing motion in X-ray is known as IMMOBILIZATION. Motion of the internal organs can only be reduced by SPEED OF EXPOSURE.

You will get motion when the patient is cold, afraid, weak, young or old, suffering pain, or positioned too long in some uncomfortable position. You must consider all of these factors and always use immobilization of some type. Just a quick draft can cause a tremor that can ruin your examination.

## PLACING INJURED SIDE NEXT TO FILM

You know that a minimum part-film distance is desirable. The side of the part which is closest to the film will be the side which will demonstrate the most detail. If your patient has an injury to the left side of his head, then the film is placed against the left side of his head. You wonder how this can be done if there is a hole in his head. There are many techniques you will learn later which will show you that there doesn't necessarily have to be extra pressure applied to injured areas. Just remember that the side closest to the film will have the greatest amount of detail.

## REMOVING ALL FOREIGN OBJECTS FROM PART

Contrary to popular belief, X-ray does not see through everything. It is important in a diagnostic examination to remove all jewelry, buttons, medallions, necklaces, hairpins, dog tags, false teeth, etc., from the area you want to examine.

During mass surveys as done in civilian health programs, where people just walk in and have their "picture" made, it is not necessary to remove such articles unless a suspicious area is seen. The reason for removal of these articles is that many fine fractures or areas of disease can be covered up by these objects and not be seen unless removed.

## DRAPING

You will ask your patients to remove any article of clothing or metal object from the area you are going to examine. You will be provided with cotton gowns which they will wear. These gowns are not starched. They are worn WITH THE OPENING DOWN THE BACK. You will also use sheets and towels for draping your patients. You will never leave any patient, male or female, UNCOVERED at any time.

## PLACING PARTS ON FILMS

Usually you will find that there are certain ways to place the part being X-rayed on your films. This is done to improve the appearance of your film just as the photographer "crops" his negative to improve the picture. Whether you place your film "lengthwise or crosswise" is dependent on how the part is found in the body.

Proper centering of the part is an important factor in the appearance of your film also. A good appearance of the part on the film is an important difference between a careful, thorough technician and a sloppy worker.

## LEADING OFF

There is a technique known as "leading off" which you will use a great deal. You will require sheets of lead of different sizes which are known as LEAD MASKS. These masks are usually cut in the department to suit their procedures. These masks are placed over a section of your film allowing you to make more than one exposure on the same film. The lead will stop the X-rays and the film under it will not be exposed. One thing you must be careful of is not to get distracting "canals". These canals are strips of white between exposures. These canals are caused by the lead being over the area on both exposures, or they may be black where they were not covered for either exposure.

Whenever you lead off, however, you want to make sure that the part X-rayed is running the same way in all views. This improves the appearance of your film. It also prevents confusion and distraction from having to turn the film around to examine different views.

## VIEW, PROJECTION AND POSITION

It is necessary for you to understand what is meant by view, projection, and position. It is generally thought that these three words are the same in meaning to an X-ray technician. You will hear terms such as lateral view, lateral projection or lateral position. This will mean that the X-ray picture is taken from the side and what you see on the film is a side view of that part. So when you are told to give the

radiologist a lateral position, view or projection, he will want a picture taken from the side.

## VIEWS USED IN EXAMINATIONS

There are four basic positions used to view parts of the body. They are anterior-posterior (front to back), posterior-anterior (back to front), lateral (from the side) and oblique (angled or rotated). Wherever possible you will take TWO VIEWS AT RIGHT ANGLES TO EACH OTHER (Figure 6-1). This will mean that you will be required to take one anterior-posterior and a lateral view, or a posterior-anterior and a lateral view, wherever possible.

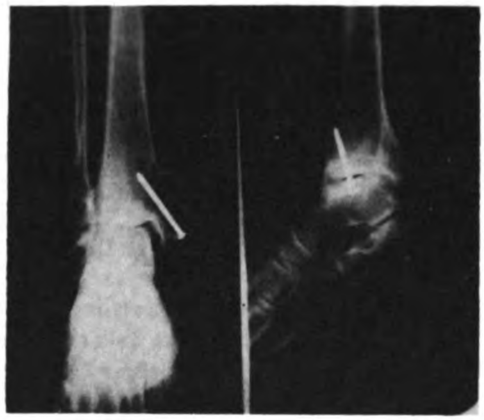


Figure 6-1 Right Angle Views

By using two views wherever possible you will have a better idea of the true size and shape of a part. You will also be able to see the extent of the injury with two views. One view may not provide you with the true picture of the injury.

There are some parts of the body which require only one view, so do not become alarmed when these are encountered. There will be exceptions to any rule.

## TUBE ANGULATION OR BODY ROTATION

Because some structures of the body cover up other structures, you will have to use the oblique views in a great many instances. These views are obtained by angling the tube or rotating the part. You will use a combination of tube angulation and body rotation in demonstrating structures such as the skull. You cannot show the sternum in a front-to-back projection because it will be pressed in the spine. To show it, you have to get it away from the spine either by angling the tube or rotating the body. Structures such as petrous pyramids, styloid processes, sella turcica and optic foramen are overlapped. By rotating the head, angling the tube or doing both, the structures can be freed from overlying structures and clearly demonstrated. When you angle the tube you must realize that you will cause some distortion. This cannot be avoided. This is a time when you are forced to use deliberate distortion. You will also see that when the body is rotated you are getting the part away from the film, and in an oblique position the picture will be distorted (Figure 6-2).

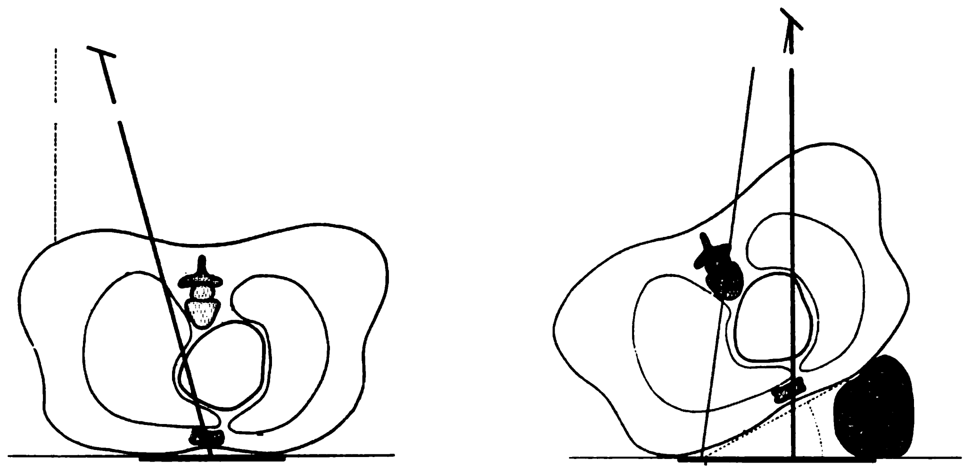


Figure 6-2 Angulation and Rotation

## IDENTIFICATION

Every film that you take must have some type of identification on it. IT MUST BE THE CORRECT IDENTIFICATION. You must know whose film you are looking at, what day it was taken, where it was taken and any other identifying markers necessary to the procedure. You will learn that it is of great importance to the radiologist to know what side you have taken. For instance, if you took the film of the patient's right leg you would put the letter "R" on the film. If you are taking a film of the patient's abdomen or spine, it is necessary for you to place a "side marker" on the film. You could use an "R" or "L" marker. This would indicate whether it was the "right" or "left" side. Then when the radiologist looked at the film he would be able to know which side was right and which was left. In case he found disease, he would know exactly what side it was on. You would not want anyone to operate on you unless he knew exactly what he was doing and WHERE! You will learn later where to use identification and what type is needed.

Failing to place proper identification on films is one of the most common mistakes made by X-ray technicians. You must try to avoid this mistake by making SURE that you have the PROPER identification on every film you take. The number on the ID tape identifies the patient. The date tells you when the film was taken. The hospital data tells you where. Side markers inform the doctor which side he is viewing.

## HUMAN RELATIONSHIPS AND YOUR PATIENT

Positioning requires the full cooperation of your patient whenever possible. You cannot get this cooperation unless you are gentle, kind, and sympathetic. Many of your patients will be afraid of your equipment or what you are going to do to them. You must keep in mind that they will not know what to do until you TELL them and SHOW them.

How successful your examination is will depend on how you learn to handle your patients. The main thing is that you are there to perform a service for them and not

judge whether it is necessary or not. ATTITUDE IS IMPORTANT IN POSITIONING.

One of the things you will encounter is lack of understanding of your instructions. DO NOT BECOME IMPATIENT. Explain distinctly, loudly and concisely the instructions necessary to complete the examination. Repeat if necessary.

Another point is unnecessary handling of your patient. You will gain more cooperation by demonstrating how you want the patient to position himself rather than pulling, pushing, twisting or punching him into position. You wouldn't appreciate it if someone grabbed your broken arm, slammed it down on a film and twisted and turned it until he was satisfied with the position. Causing pain to an injured part may make the patient resentful, or he may become stiff, scared and shy.

Your patient will be able to do his own positioning with gentle encouragment, persuasion and demonstration. In many instances, you will not even have to touch him.

When you know that he will be required to sustain some pain, do not hesitate to tell him so. He'll find out anyway and you'll go on his list very quickly.

## TERMS USED IN POSITIONING

### HOW POSITIONS ARE NAMED

Do you know what an anteroposterior oblique of the skull means, or the fronto-occipital view of the skull, or the inferolateral projection of the neck of the femur, or possibly Stenver's position of the petrous pyramids? You will encounter these terms and ones similar to them in studying radiographic positioning. When you hear these you will picture in your mind the position you will be expected to use.

You see from the above examples that you have names which refer to DIRECTION, ANATOMICAL LOCATION, AND PROPER NAMES OF MEN. In those that are designated with direction and anatomical location, the position is indicated by the prefix (or first word) and the suffix (last word). These words refer to where the central ray enters the part and where it comes out. Thus, in the inferolateral position the central ray enters the inferior surface and comes out on the lateral surface. In a fronto-occipital view, the central ray enters the frontal bone and comes out through the occipital bone. Now the use of a proper name denotes a particular position that you must know. When you see the name FORD you think of an automobile without the word automobile being there. You see a picture of a car in your mind. You will do the same thing when you see a proper name for a position. These particular positions are usually named for the men who developed them. So when you see Stenver's position for the petrous pyramid you will picture a definite position in your mind. Some men have developed more than one position, so the structure to be radiographed will usually follow the person's name. The term anteroposterior oblique will picture one of two possibilities in your mind. One, that the central ray enters the front and comes out the back with the part in an oblique position, or two, the central ray angled in an oblique direction with the part in an anteroposterior position.

## BODY PLANES

Body planes are imaginary lines dividing the body into various portions. They are used in orientating the body to the tube, film or table. There are five body planes used in radiographic positioning (Figure 6-3). They are the MEDIAN PLANE, CORONAL PLANE, SAGITTAL PLANE, MID-AXILLARY PLANE AND TRANSVERSE PLANE.

MEDIAN PLANE. This plane is an imaginary line which passes through the exact center of the body from front to back. It divides the body into EQUAL right and left halves. The plane is also called the mid-sagittal plane.

CORONAL PLANE. The coronal plane is an imaginary line which passes through the body from side to side dividing it into front and back sections.

SAGITTAL PLANE. Any imaginary line which runs from front to back and is PARALLEL to the median plane. Any number of sagittal planes can be used. They divide the body into UNEQUAL right and left portions.

MID-AXILLARY PLANE. This plane is used a great deal in positioning. It is a plane that begins in the armpit and divides the body. It is really a continuation of the coronal plane. You will use it more than the coronal plane.

TRANSVERSE PLANE. A transverse plane is any plane passing in a horizontal direction and at right angles to the median plane. This divides the body into superior and inferior sections. You can have any number of these planes. They give you a cross section of a part.

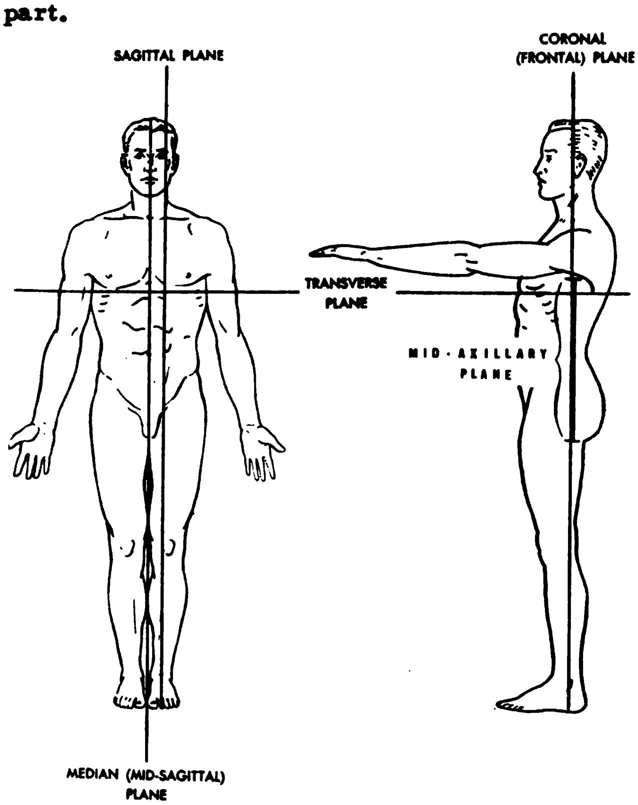



Figure 6-3 Body Planes

**BODY POSITIONS**

**You will use five basic body positions. These are the SUPINE, PRONE, LATERAL RECUMBENT, OBLIQUE, AND ERECT POSITIONS (Figure 6-4).**

**SUPINE - The patient will lie down with his back on the table.**

**PRONE - The patient lies on his stomach.**

**LATERAL RECUMBENT - patient will be lying on either side.**

**OBLIQUE - The patient will assume a position between supine and lateral or between prone and lateral.**

**ERECT - The patient will be either sitting or standing.**

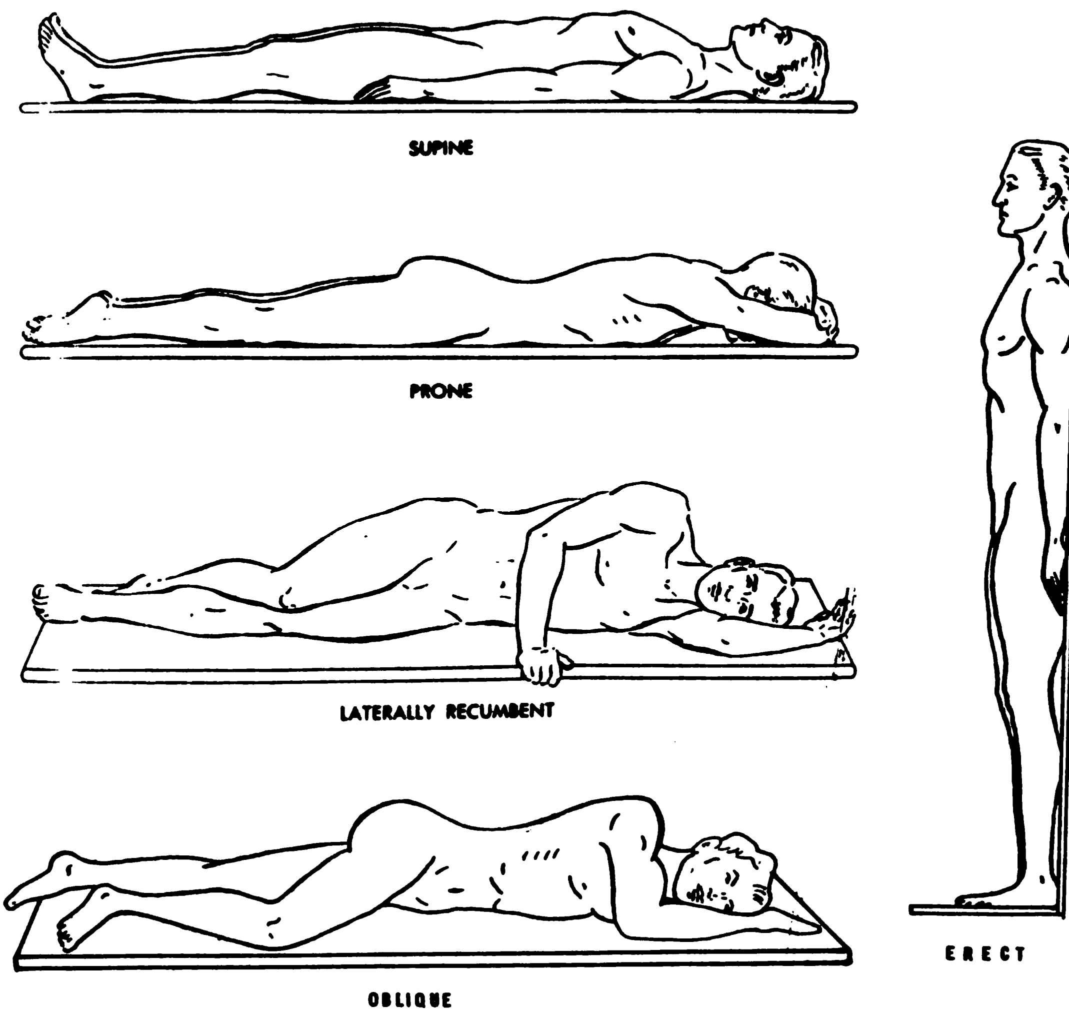



**Figure 6-4 Body Positions**

## BODY MOTIONS

These terms are used in preparing the various parts for positions and refer both to the motion of the part and the position of the part after motion has been completed.

SUPINATION - Turning the palm up.

PRONATION - Turning the palm down.

ADDUCTION - Moving toward the median line.

ABDUCTION - Moving away from the median line.

FLEXION - Drawing up or shortening.

EXTENSION - Extending out or lengthening.

INVERSION - Turning sole of foot toward median line.

EVERSION - Turning sole of foot toward the lateral side.

## BODY LANDMARKS

Body landmarks are structures used to locate other body structures. The landmarks are used just as a church, tree, or a certain intersection on a highway is used to locate places for you in the country. They point the way or designate the place you are looking for. There are three types of body landmarks.

- Those you can see - external auditory meatus, knuckles or heads of the metacarpals.
- Those you can feel - mastoids, greater trochanter, anterior-superior iliac spine.
- Those that are related to two other landmarks - head of femur and ninth thoracic vertebra.

## BODY TYPES

You will meet a variety of body types. Patients will come to you who are fat, thin, short or tall. These patients will create modifications of the positions to some extent. The location of the different organs will vary so you must be able to recognize these various body types (Figure 6-5). These body types, although four in number, usually fall within three general classifications.

STHENIC - the average individual with medium build.

HYPERSTHENIC - the short, stocky individual. His chest will be short so his lung fields will be small from top to bottom. His stomach will lie higher and be more horizontal in position.

**HYPOSTHENIC - the slim, thin individual. He will be tall and skinny. His lungs will be long from top to bottom. His stomach will be more vertical and extend down farther in the abdominal cavity.**

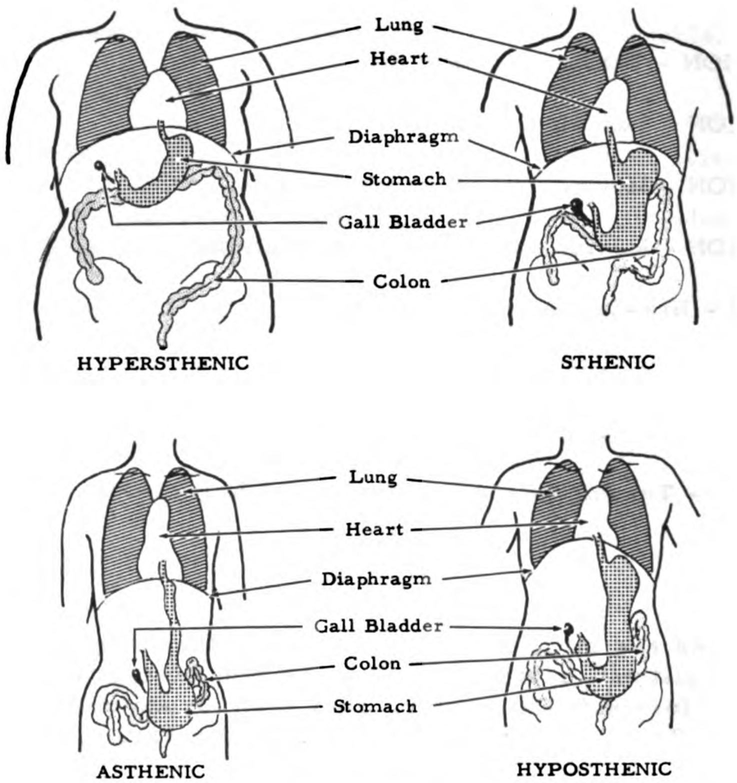



**Figure 6-5 Body Types**

## BODY REGIONS

**The abdomen of the body is divided into various regions. This division is used in radiographic positioning to localize various organs in the body. (Figure 6-6).**

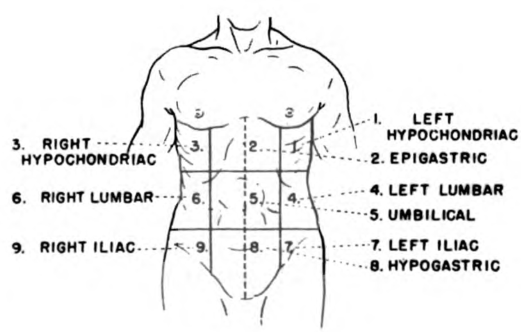



**Figure 6-6 Body Regions**

## SEX CHARACTERISTICS

There will be differences in sex which you will have to realize. This is usually important in placing central rays and centering films.

The male landmarks are more prominent than those of females. The tone of the body is harder and the structures beneath the muscles are more prominent. The male pelvis is narrow. The angle of the neck and head of the femur is less than in the female. The bone structure is larger.

The female extremities are smoother and more conical in appearance than the male. There are normal deposits of fatty tissue in the buttocks, in the area of the upper thoracic vertebra, in the thighs and in the region of the lower abdomen. The female breast can create problems in examination of the chest. The female bone structure is smaller and not as rough as that of the male. The pelvis is wider due to the birth function. The angle of the neck and head of the femur is greater because of the wider pelvis structure and the shaft angles medially more than in the male.

The lumbosacral joint will be wider in the female than in the male because the sacrum is more posteriorly angled.

These characteristics should be considered as they will effect your positioning and techniques.

## ROUTINE VERSUS SPECIAL POSITIONS

Each clinic will have certain positions that are used each time a part is examined. These positions are called routine. These routine positions can vary from clinic to clinic. Special positions are positions used to obtain further information when suspicious evidence is indicated but not conclusively demonstrated on routine films. Also special positions are used to demonstrate structures that are not examined frequently.

What is routine and what is special will be determined by your clinic.

## MODIFYING POSITIONS

It is not wise to regiment your mind on what is right and what is wrong in positioning. You will find that there are many variations from "standard" positions. The whole purpose of X-ray is to demonstrate structures requested by the radiologist. Positioning becomes an art as later experience will show you.

Modifications of your positioning techniques will confront you constantly. You may find that the patient's organs or structures vary and your standard or routine projections will not demonstrate what is needed. You may find your patient's injuries will not allow him to assume the normal routine positions. You may find that your equipment will limit the use of some of the accepted routine positions. You will be able to devise new means of demonstrating structures that will show if you have learned your lessons well. A thorough knowledge of anatomy is essential. You must also constantly observe your films so that you can identify structures you have demonstrated and correct them. REMEMBER YOUR TUBE-PART-FILM ALIGNMENT

**PRINCIPLE.** When you cannot take a film in one position you must take it in another. You will see some guides as to how you can modify positions as you continue studying this chapter.

## BEHIND AND AHEAD

You have now been exposed to some of the basic positioning knowledge that is necessary to fully understand what lies ahead. This knowledge will carry more meaning as you progress.

In the next section you will begin to study positions used to demonstrate the structures of the body. Keep in mind that these positions can be modified. It will depend upon the preference of your radiologist which positions you use, what degree of angulation, etc. Be sure to study the illustrations very carefully and use the radiographs to learn how the structures look in the different positions. It isn't going to be much help for you to take a film and not be able to identify what you've taken. It is here that your knowledge of anatomy will become real and useful. You have learned positioning only when you can close your eyes and visualize in your mind all of the steps used in each position.

## POSITIONS

### STEPS IN POSITIONING

In every examination you make there will be certain steps which you will repeat every time. It will be easier to learn positioning if you will learn these steps first.

Film. It is obvious that you are going to need film. The size, type and number will be determined by the size of the part you wish to show, the thickness of the part and type of technique to be used, and the number of film required by the number of exposures you are going to take. Look at your request form. If it requests an examination of a hand for a possible fracture, you would do the following things. Look at the hand. Is it small or overly large? If small, you would use an 8 x 10 film; if large, you would use a 10 x 12 film. Always use a film large enough to cover the area you wish to see. Do not use a big film for a little part. You are wasting MONEY. You know you are going to examine a hand. You know that a hand is under eleven centimeters. You know that you would use a cardboard holder. Generally, a posterior-anterior and an oblique view is used in examining the hand. This will require two films. You can see, then, that you would use two 8 x 10 cardboard holders.

Measuring the Part. Although this is primarily used to determine your exposure, you will do it during the positioning phase. Sometimes you are required to measure the part while it is in position, but usually you try to measure it first. This way you can set up your control panel and your patient will not be required to maintain a position any longer than necessary.

Positioning Patient. You will place your patient in the body position you are

going to use. You center him to the table or to the film depending upon the technique you are using. He will be supine, prone, lateral recumbent, oblique, or erect, depending upon the part. You will center the body plane you are using to orient the body to the film or table.

Positioning the Part. After you have the patient in a certain body position, you will adjust the part to its proper position. For the hand the patient would be seated erect and then the hand positioned on the film in a prescribed manner.

Using Landmarks for Centering CR and Film. You will always have to know what landmarks you are going to need to center your film and where to direct your central ray. You should always ask yourself where you center the film or where your CR enters and comes out.

Using Immobilization. You must always use some type of immobilization. This may be mechanical devices for holding or inducing comfort such as pads, etc., or even suspension of breathing. Make sure that each position is immobilized.

Placing Identification. Remember always to place identification marks on your film, with any other type of markers which are necessary to show what has been done in the examination. The identification should always be placed in an area which will not be covered by the part whenever possible.

Final Check. A rapid visual check of your control panel must be made to be sure your KVP, MA and time are correct. Check final alignment of your tube. Check your tube from two sides to make certain of proper alignment. Check position, film and part centering, immobilization and identification.

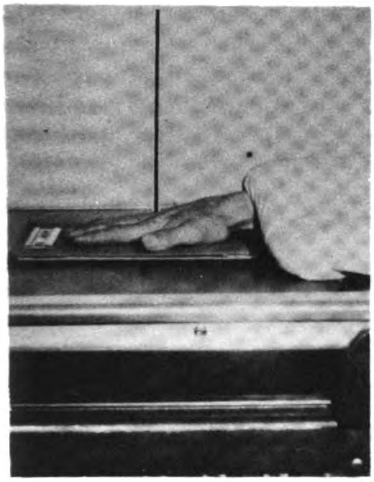
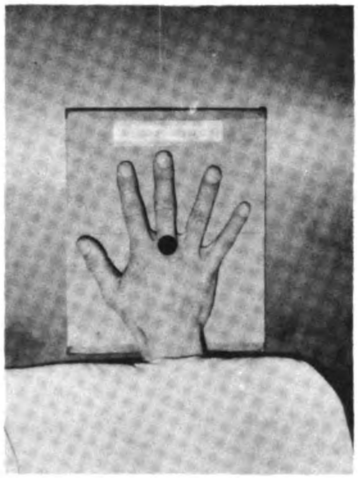
# THE HAND

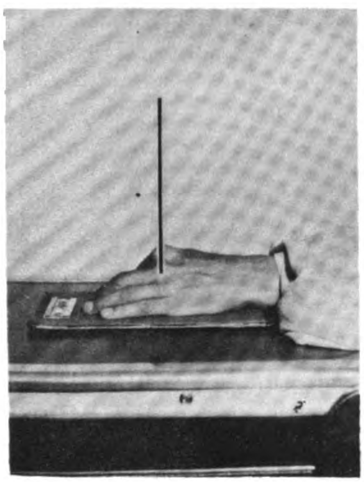
## POSTERIOR-ANTERIOR VIEW OF THE HAND

Use an 8 x 10 cardboard film placed lengthwise, or a 10 x 12 crosswise with a lead mask. Seat the patient at the end of the table. Place the hand with palm down and fingers spread. The head of the third metacarpal is centered to the center of the film. The central ray is directed perpendicular to the head of the third metacarpal. Sandbags are placed over the forearm to immobilize the part. ID is placed at the top center. The part is measured through the knuckles.

## OBLIQUE VIEW OF THE HAND

The oblique view of the hand is identically the same as the posterior-anterior view with one exception; place the hand so the back of it forms an angle of 45° to the film.

## THE THUMB

### ANTERIOR-POSTERIOR VIEW OF THE THUMB

Use an 8 x 10 cardboard film crosswise with a lead mask. Seat the patient at the end of the table. Have the patient rotate the hand in extreme internal rotation until the posterior surface of the thumb is against the film. Center the first metacarpophalangeal joint to the center of the film. Direct your central ray perpendicular to the first metacarpophalangeal joint. Sandbags are placed under the elbow and at tips of fingers to provide immobilization and comfort. ID to one side or in the center of the film. Measure through the first metacarpophalangeal joint.

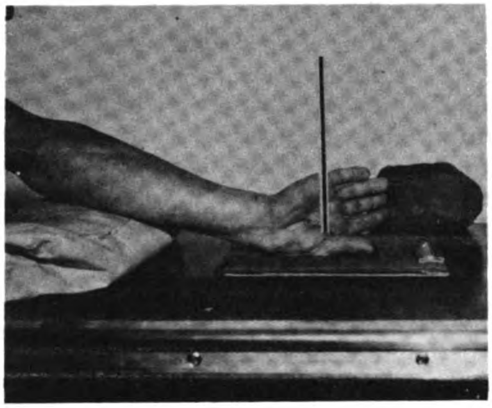
### LATERAL VIEW OF THE THUMB

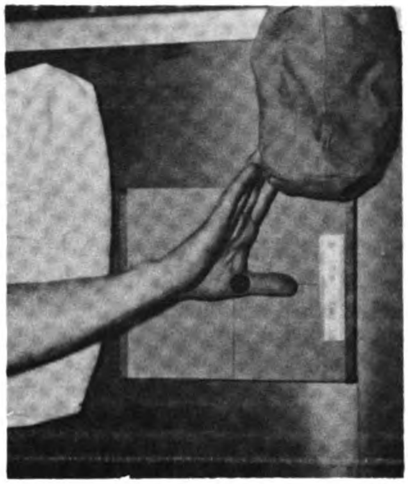
Use an 8 x 10 cardboard film crosswise with lead mask. Seat the patient at the end of the table. Place the thumb so that the long axis of the thumb is lined along the mid-length of the film. Hand is flat and then the patient is instructed to draw fingers up until the thumb is in a true lateral position. Center the first metacarpophalageal joint to the center of the film and direct the central ray perpendicular to that point. ID on side or in the center. Use sandbags over the forearm to immobilize the part. Measure through the first metacarpophalageal joint.

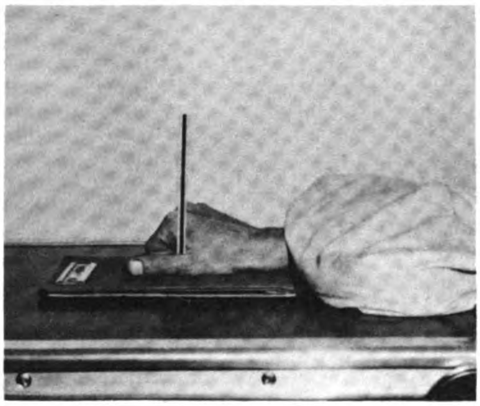
## THE WRIST

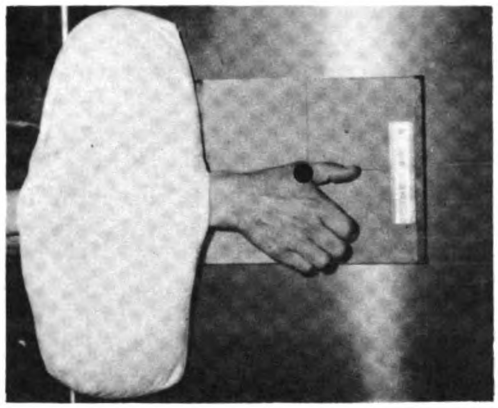
### POSTERIOR-ANTERIOR VIEW OF THE WRIST

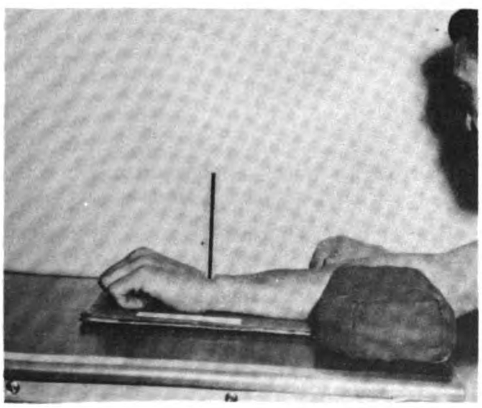
Use an 8 x 10 cardboard film placed lengthwise or crosswise if two or more views are to be placed on the same film. Seat the patient at the end of the table. Have the patient double his fist and place the carpal area to the center of the film. The palm is down. Direct the central ray perpendicular to the center of the carpal area. Place a sandbag over the forearm for immobilization. ID is placed on the side. The part is measured through the carpal area.

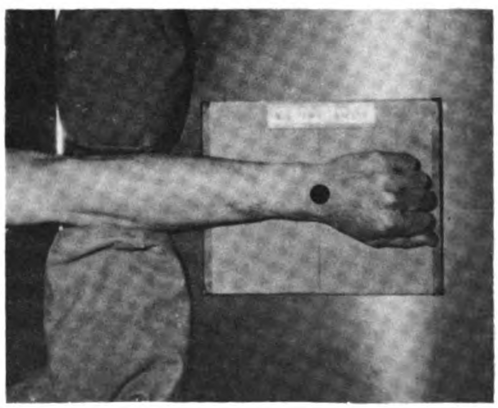












## LATERAL VIEW OF THE WRIST

Use an 8 x 10 cardboard film placed lengthwise or crosswise if two or more views are to be placed on that same film. Seat the patient at the end of the table. Place the hand in a lateral position with fingers extended together or clenched. The ulnar side of the forearm is next to the film. Center the carpal area to the center of the film. Supinate the wrist 5 degrees to superimpose the styloid processes. Direct the central ray perpendicular to the carpal area. ID on the side. Use sandbags over the forearm and on side of the fingers if extended. Measure through the carpal area.

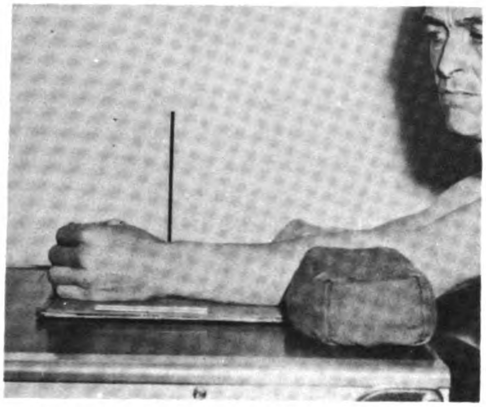
## PRONATED OBLIQUE VIEW OF THE WRIST

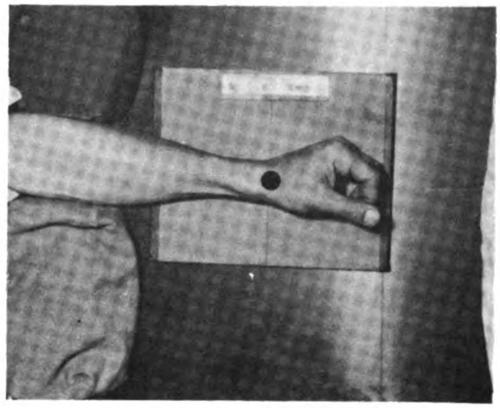
Use an 8 x 10 cardboard film placed lengthwise or crosswise if two or more views are to be placed on the same film. Position the same as for a PA view, but place the wrist at an angle of 45 degrees to the film.

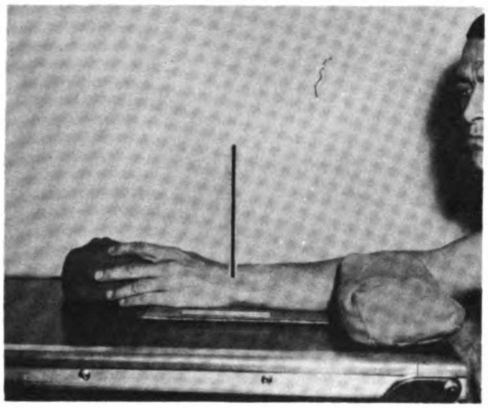
# THE FOREARM

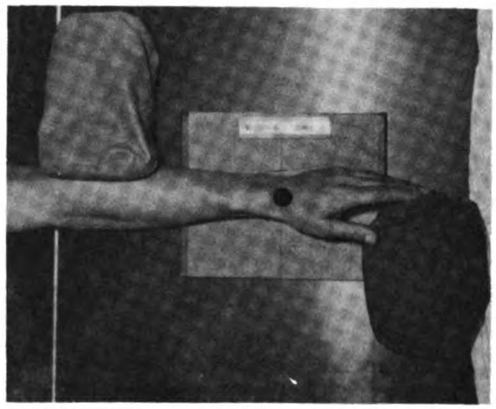
## ANTERIOR-POSTERIOR VIEW OF THE FOREARM

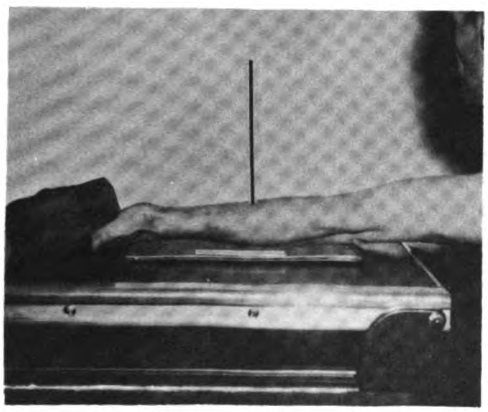
Use a 10 x 12 cardboard film placed lengthwise with a lead mask. Seat the patient at the end of the table. Place the arm with the palm of the hand up on the table. Include the joint nearest the injury on the film. Direct the central ray perpendicular to the center of the unmasked half of the film. The forearm should be centered to the median line of the film. Place sandbags over hand and humerus. The ID goes on the side or in the center between the views. Measure through the middle of the forearm.

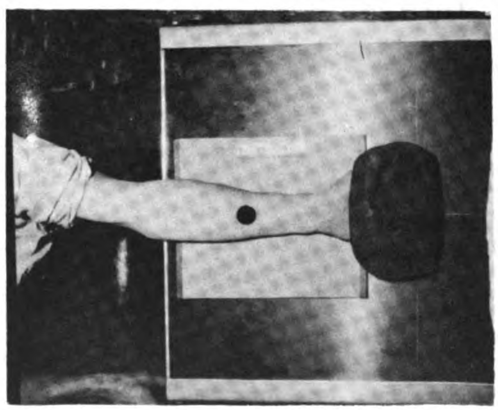












## LATERAL VIEW OF THE FOREARM

Use a 10 x 12 cardboard film placed lengthwise with a lead mask. Seat the patient at the end of the table. Bend elbow 90 degrees and turn the hand and wrist to the lateral position. Ulnar surface of the forearm on the film. See that the bones go the same way as the AP view. Supinate the forearm 5 degrees to superimpose the styloid processes. Direct the central ray perpendicular to the center of the film. Place ID on the side or in the center between the views. Sandbags are placed on either side of the hand if the fingers are extended and over the humerus. Humerus is as close to the table as possible. Measure through the center of the forearm.

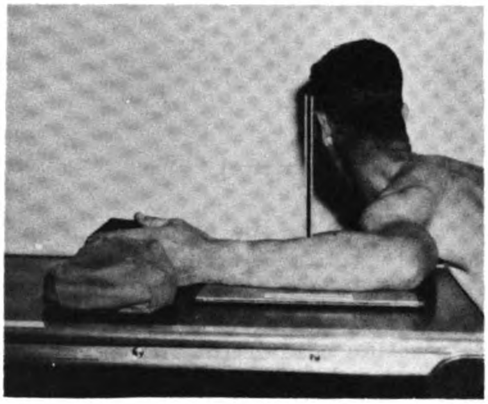
# THE ELBOW

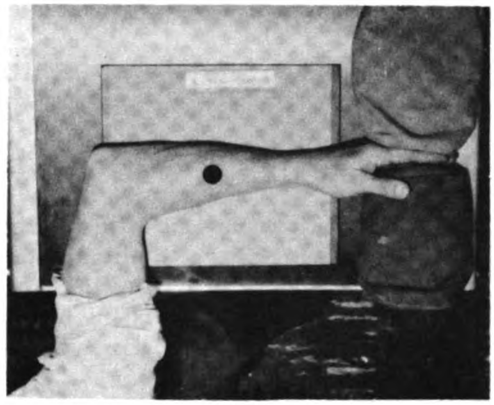
## ANTERIOR-POSTERIOR VIEW OF THE ELBOW

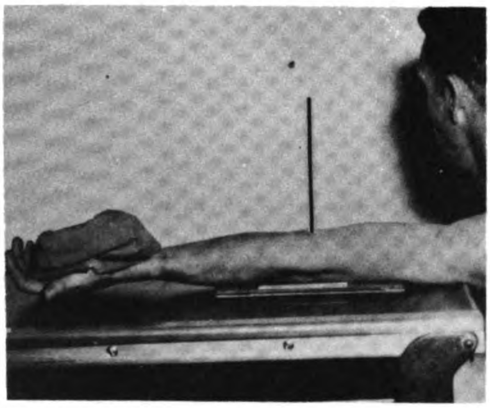
Use an 8 x 10 cardboard film placed lengthwise or crosswise if two views are used on the same film. Seat the patient at the end of the table. Have patient extend his arm out with the palm up. Center the medial epicondyle of the humerus one-half inch below the center of the film. Direct the central ray perpendicular to the center of the film through the joint. Use sandbags in the hand and over the arm. ID is on the side or in the center between the views. Measure through the elbow joint.

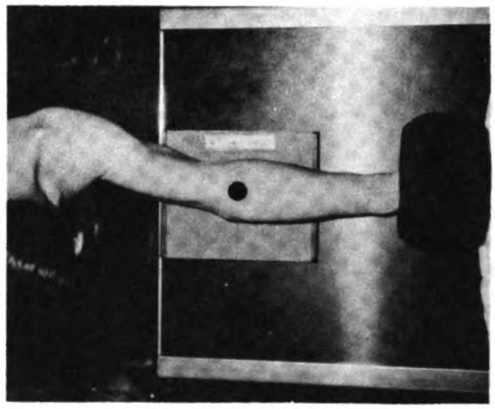
## LATERAL VIEW OF THE ELBOW

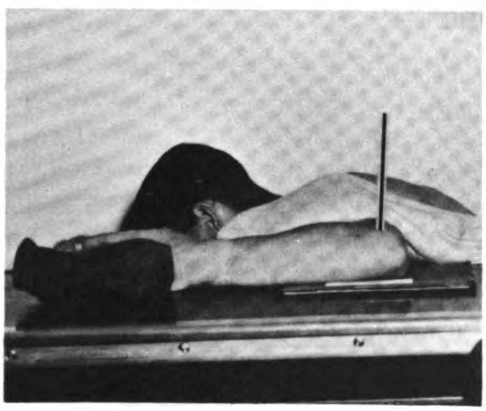
Use an 8 x 10 cardboard film placed lengthwise or crosswise if two views are used on the same film. Seat the patient at the end of the table. Have the patient bend his elbow 90 degrees. Center the medial epicondyle of the humerus to the center of the film. Double the fist and place the forearm in the lateral position. Direct the central ray perpendicular to the center of the film. Place sandbags on either side of the hand and over humerus. ID on the side or in the center between the views. Measure elbow joint.

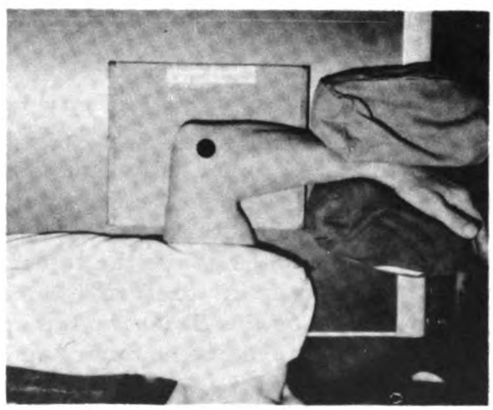












## THE HUMERUS

### ANTERIOR-POSTERIOR VIEW OF HUMERUS (Lower two-thirds)

Use a 10 x 12 cardboard film placed lengthwise. Place the patient in a supine position on the table. Place the humerus to the midlength of the film with the palm up. Include the elbow joint on the film. Direct the central ray perpendicular to the center of the film. Have the patient stop breathing during the exposure to immobilize him. Place a sandbag in the palm. Place the ID on the side of the film. Measure through the middle of the humerus.

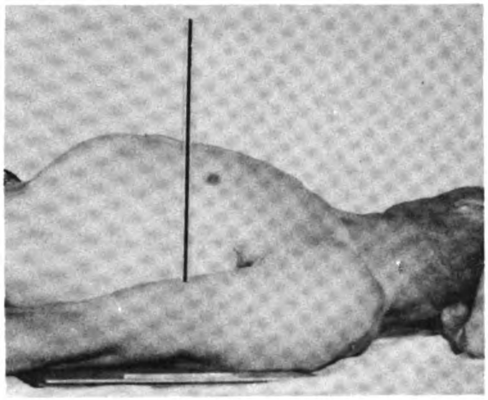
### LATERAL VIEW OF THE HUMERUS

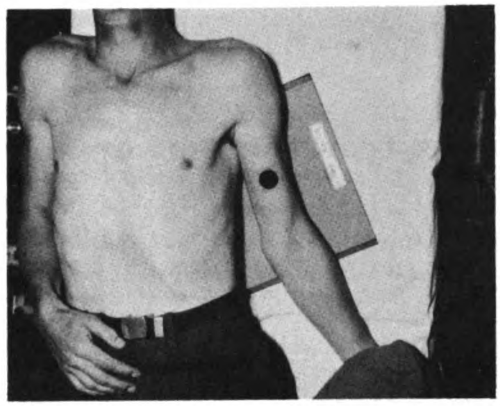
Use a 10 x 12 cardboard film lengthwise. Place the patient in the supine position. Have the patient place the forearm over the abdomen. Build up the film with sandbags or blocks until the arm is in a true lateral position. Center the arm to the midlength of the film. Direct the central ray perpendicular to the center of the film. Place the ID on the side. Measure through the center of the humerus.

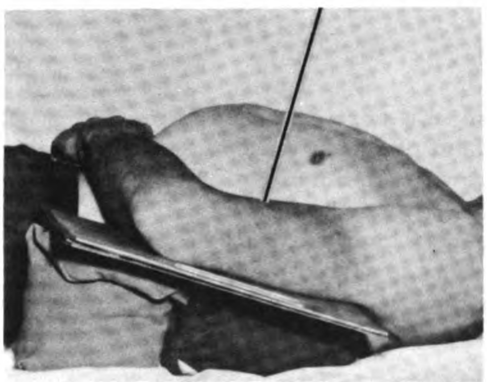
## THE SHOULDER

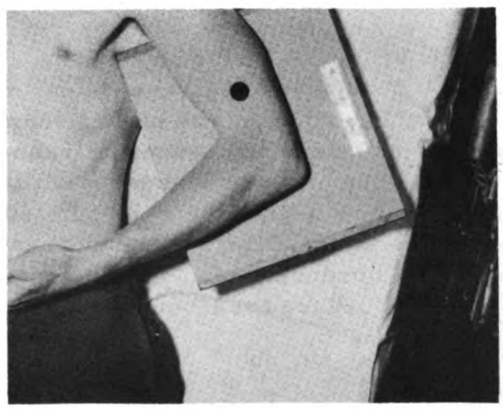
### ANTERIOR-POSTERIOR VIEW OF THE SHOULDER

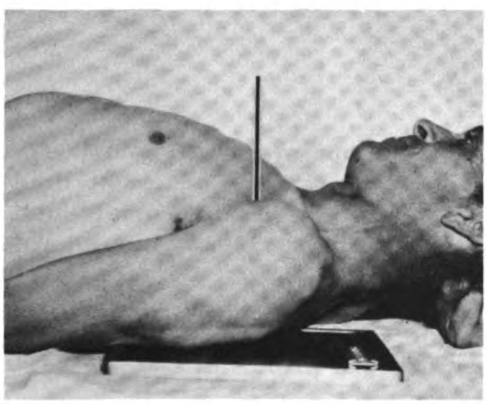
Use a 10 x 12 cassette film placed crosswise. Place the patient in the supine position on the table. Center the shoulder joint to the midline of the table. The joint is located slightly medial to acromion process. Place the film so that the upper border of the film is 2 inches above the top of the shoulder. Direct the central ray perpendicular to the center of the film. Suspend the breathing during the exposure for immobilization. Place the ID on the top space above the shoulder. Measure through the shoulder joint. There are a number of routine views used with this basic position. Some rotate the body up. Others take one film with the palm of the hand down and another with the palm up to show the outline of the greater and lesser tuberosities.











# THE SCAPULA

## ANTERIOR-POSTERIOR VIEW OF THE SCAPULA

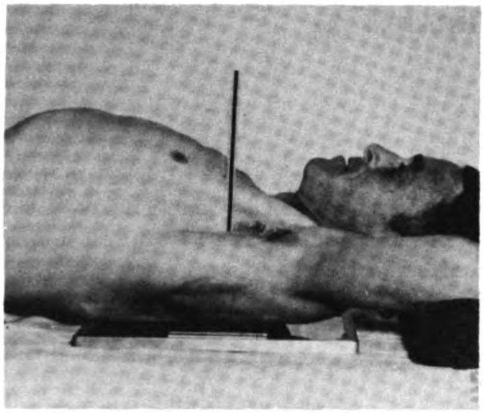
Use the AP view of the shoulder. This can be varied by placing the hand behind the head which draws the scapula laterally away from the rib cage.

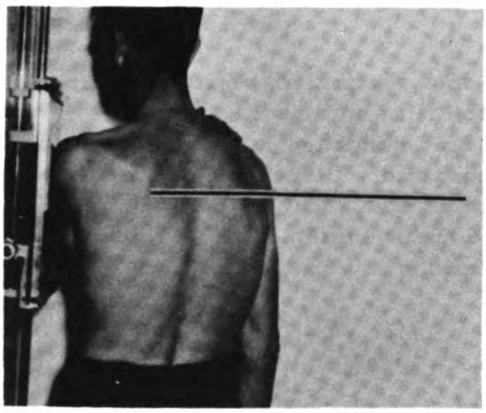
## LATERAL VIEW OF THE SCAPULA

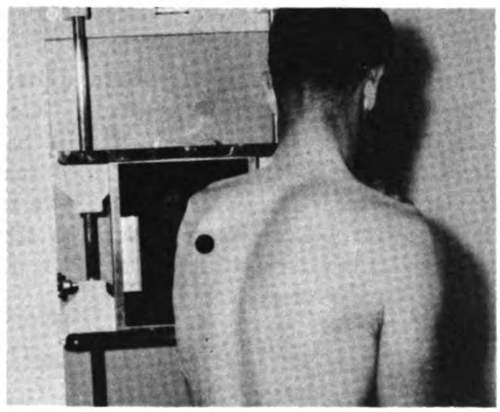
Use a 10 x 12 cassette placed lengthwise in a vertical cassette holder. Have the patient in a standing position. Grasp the hand of the injured side and place on the opposite shoulder. Rotate the body until the vertebral border of the scapula is perpendicular to the film. Place the film so that the upper border is 2 inches above the top of the shoulder. Direct the central ray one-half inch medially from the center of the vertebral border. It will be horizontal. Have the patient suspend breathing during the exposure. Place the ID on the posterior side. Measure through the central ray.

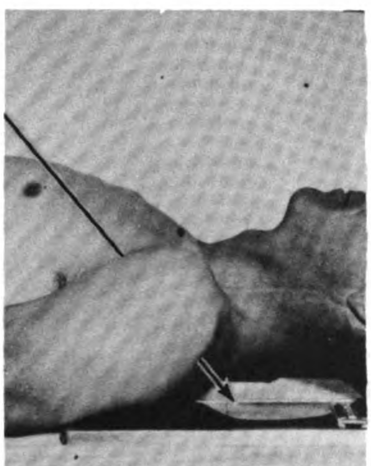
## CORACOID PROCESS OF THE SCAPULA

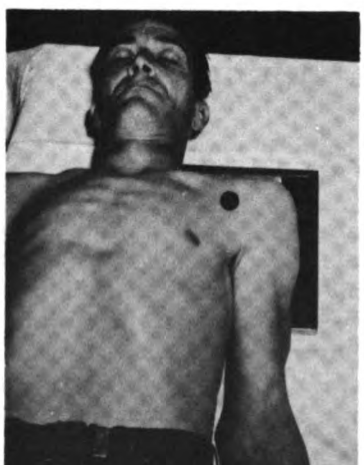
Use an 8 x 10 cassette placed lengthwise in the bucky tray. Place the patient in the supine position with the coracoid process centered to the center of the white line on the table. The coracoid process is on the level of the manubrial notch and about 1 inch medial to the acromion process. Direct the central ray at an angle of 25 degrees toward the head so that it passes through the tip of the coracoid process. Center the film to coincide with the central ray. Use an extension cone to get a 6 inch cone field. Have the patient suspend breathing during the exposure. The ID is "burned" in at the top of the film. The part is measured through the central ray.

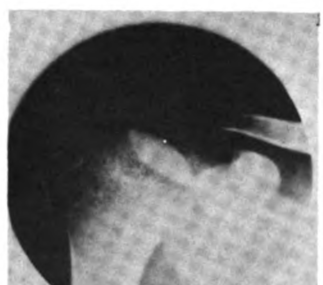












## THE HUMERAL HEAD

### LATERAL TRANS-THORACIC VIEW

Use a 10 x 12 cassette placed lengthwise in a vertical cassette holder. The patient is standing in a lateral position. The affected shoulder is centered to the film which is placed in a vertical cassette holder. The uninjured arm is placed over the head. Central ray is directed horizontally to the axilla nearest the tube. Shallow breathing is allowed so that the movement of the chest will blur out the rib shadows. ID is put on the anterior side of the film. Measure through the axilla and include the injured arm.

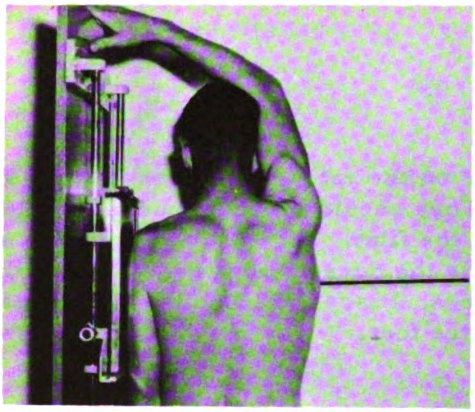
## ACROMIOCLAVICULAR ARTICULATION

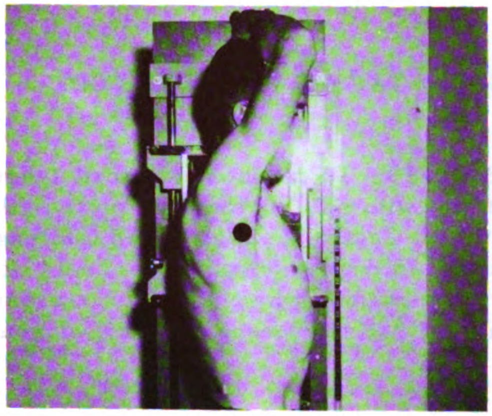
Use a 14 x 17 cassette placed crosswise in a vertical cassette holder. Place the patient in a PA standing position. Center the film so that the top of the shoulder is in the center of the film. Have the patient hold sandbags in his hands so that the shoulders are rounded and dropped as far as possible. Direct the central ray horizontally to the center of the film. Have the patient suspend breathing during the exposure for immobilization. Place the ID above the shoulder. Measure through the acromioclavicular articulations. Both articulations are taken on the same film at the same time for comparison.

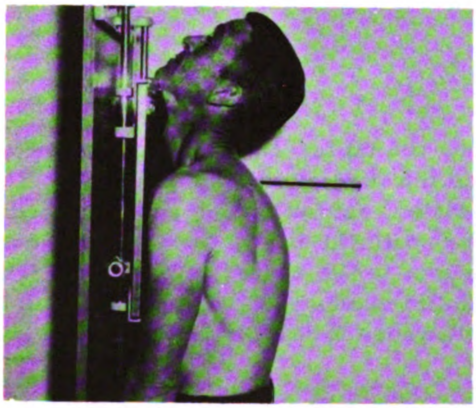
## THE CLAVICLE

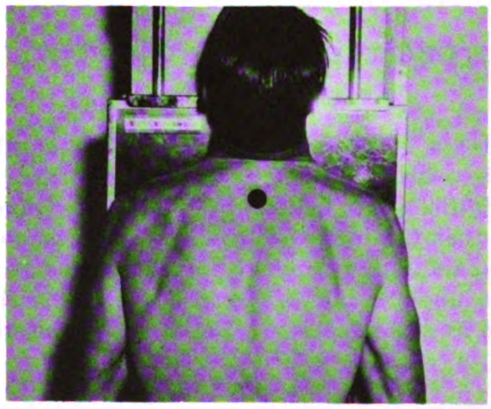
### POSTERIOR-ANTERIOR VIEW OF THE CLAVICLE

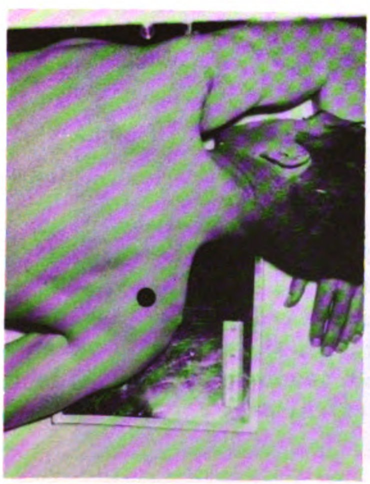
Use a 10 x 12 cassette placed crosswise in the bucky tray. The patient is placed in a prone position. A sagittal plane passing through the center of the clavicle is centered to the white line of the table. The arm of the injured side is alongside of the body. The head is turned away from the injured side. The film is placed so that the upper border is 2 inches above the shoulder. Direct the central ray to the center of the film. Have the patient suspend breathing during the exposure for immobilization. ID is placed above the shoulder. Measure through the central ray.

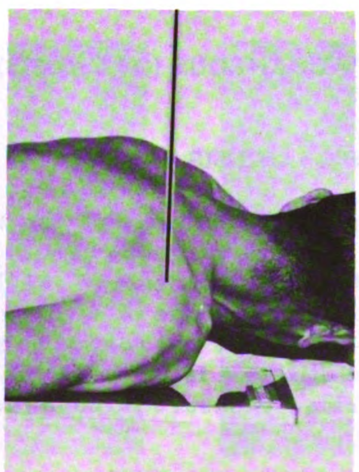












# THE FOOT

## DORSOPLANTAR VIEW OF THE FOOT

Use a 10 x 12 cardboard placed lengthwise on the table. Have the patient sit on the table with sole of foot flat on the film. Toes should be about one inch below top of film. Center the foot to the midlength of the film. Direct the central ray at an angle of 15 degrees toward the heel. It enters the dorsum of the foot. Have the patient support the leg by placing arms around knees. Place the ID on the side. Measure the central ray through the mid-dorsum of the foot.

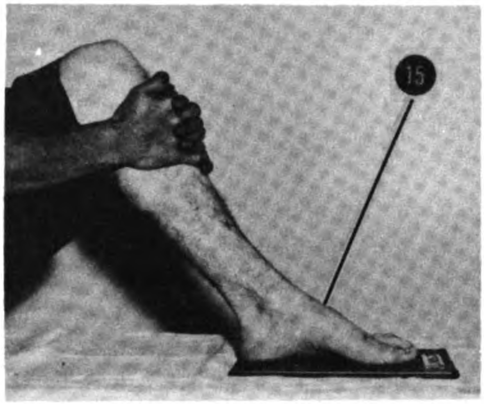
## MEDIAL OBLIQUE VIEW OF THE FOOT

Use a 10 x 12 cardboard placed lengthwise on the table. Have the patient sit on the table with sole of foot flat on the film. Place the medial edge of the foot to the lateral side of the center of the film. Have the patient rotate his leg and foot medially so that the foot will form an angle of 45 degrees with the film. Direct the central ray perpendicular through the mid-dorsum of the foot to the center of the film. The toes are about 1 inch from the top of the film. Build sandbags up under the knee to provide immobilization. Place ID on the side. Measure through the central ray.

# THE CALCANEOUS (OS CALSIS)

## INFERIOR-SUPERIOR VIEW OF OS CALSIS

Use an 8 x 10 cardboard placed lengthwise on the table. Patient is seated on the table with the leg extended. A strap of gauze or a belt is placed around the ball of the foot and pulled by the patient until the sole of the foot is perpendicular to the film. The central ray is directed at an angle of 40 degrees toward the back of the heel. It enters the junction of the middle and posterior thirds of the foot. Be sure the toes are straight up. Immobilization is by the strap and sandbags on each side of the leg. The ID goes on the side. Measure through the central ray.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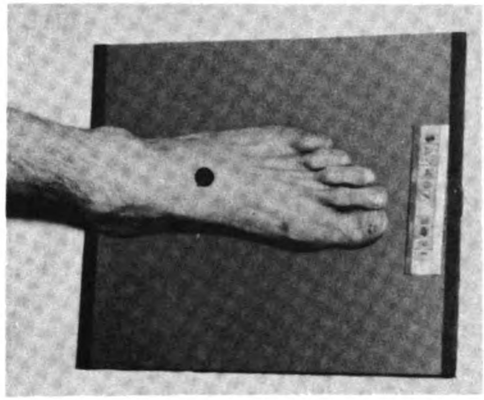

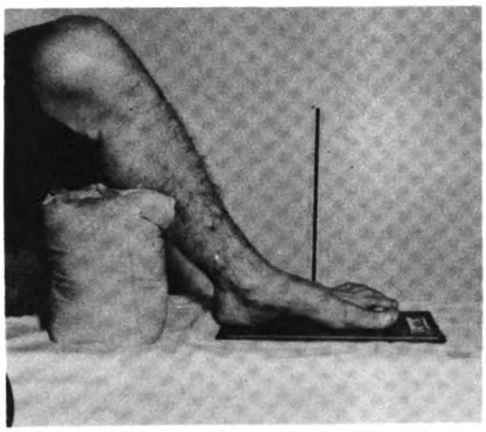

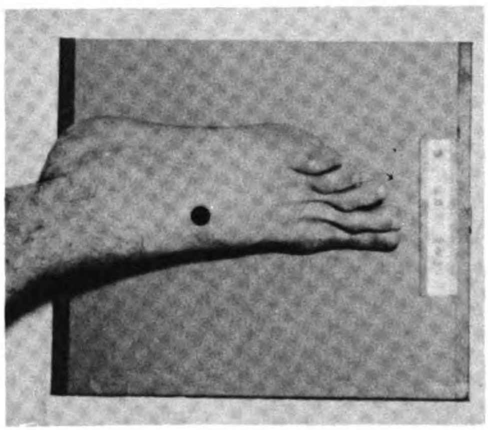

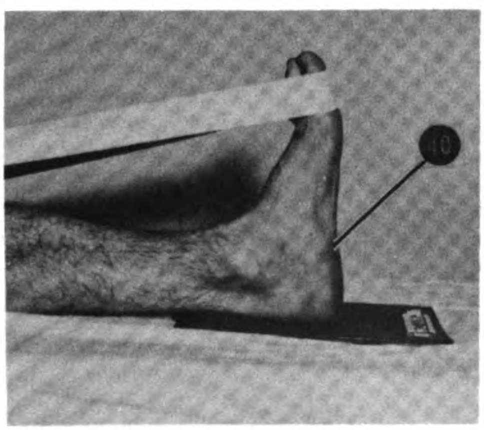
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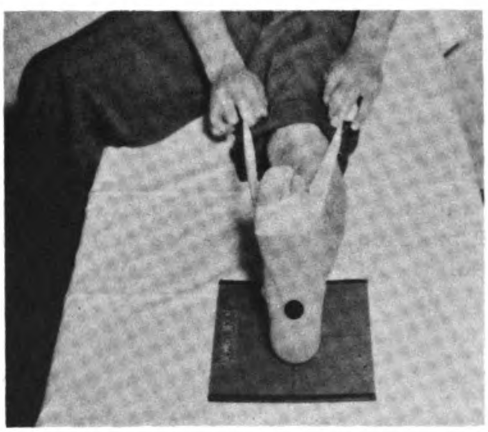


# THE ANKLE

## ANTERIOR-POSTERIOR VIEW OF THE ANKLE

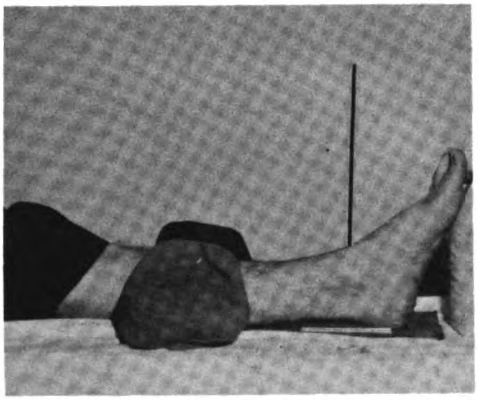
Use an 8 x 10 cardboard placed lengthwise on the table. Patient sits on the table with the leg extended. Toes are straight up to be certain of a true anterior-posterior position. The lateral malleolus is about one-half inch above the center of the film. Direct the central ray perpendicular to the center of the film. Sandbags are placed on either side of the leg and at the toes for immobilization. ID is placed oh the side. Measure through the ankle joint.

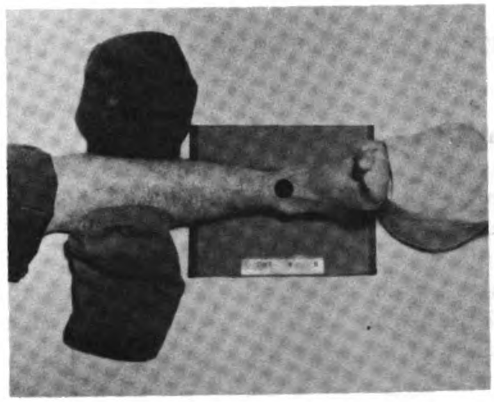
## LATERAL VIEW OF THE ANKLE

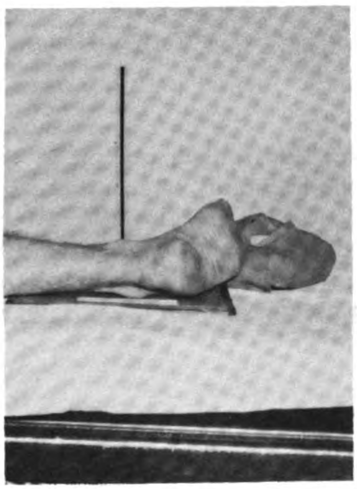
Use an 8 x 10 cardboard placed lengthwise on the table. Place the patient in a lateral recumbent position. The good leg is flexed over the bad one. The lateral malleolus is centered to the center of the film. Sandbags are placed under the toes for immobilization. ID is placed on the side. Measure through the ankle joint.

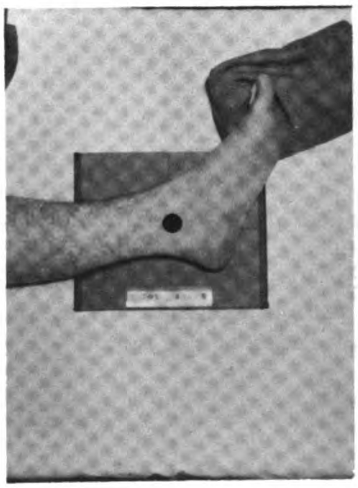
## MEDIAL OBLIQUE VIEW OF THE ANKLE

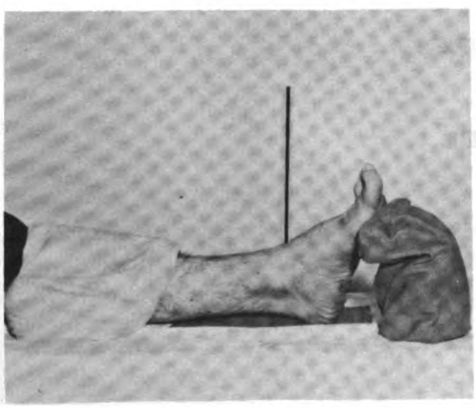
Use an 8 x 10 cardboard placed lengthwise on the table. Have the patient assume the AP position. Then rotate entire limb so that the ankle is at an angle of 45 degrees to the film. All three views can be placed on a crosswise 10 x 12 film if desired or necessary.

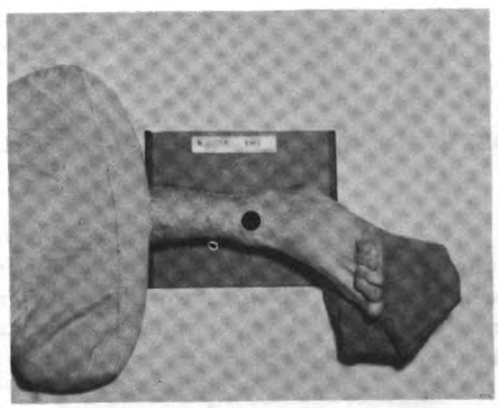












# THE LEG

## ANTERIOR-POSTERIOR VIEW OF THE LEG

Use one-half of a 14 x 17 cassette placed lengthwise. (A 14 x 17 is used because you will usually not find a 14 x 17 cardboard holder in the Air Force). Place the patient in the supine position with leg extended out. The toes are straight up. Center the leg to the midlength of the unmasked half of the film. Include the joint nearest the site of injury. Place the film so that at least two inches of the joint included is on the film. Direct the central ray perpendicular to the center of the film. Place sandbags on either side of the foot to keep toes up and provide necessary immobilization. ID is on the side or in between the two views. Measure through the middle of the leg.

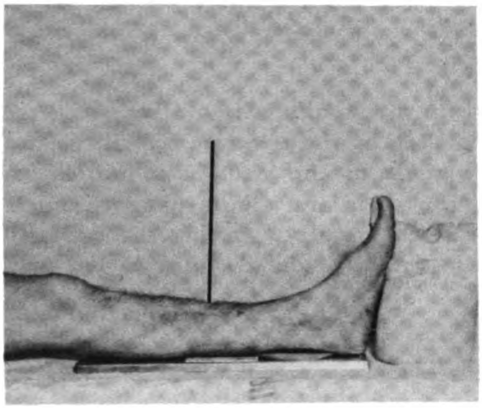
## LATERAL VIEW OF THE LEG

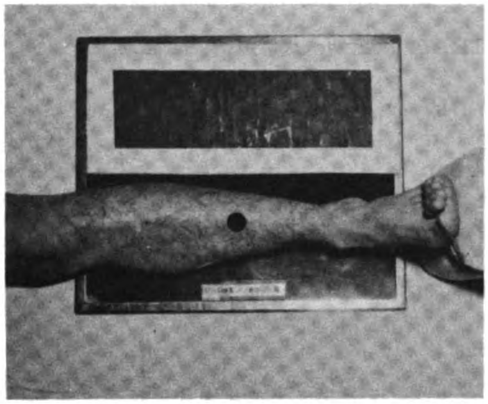
Use one-half of a 14 x 17 cassette placed lengthwise. Patient is placed in the lateral recumbent position. The good leg is flexed over the bad one. Center the leg to the midlength of the unmasked half of the film. Include joint as in AP view. Place film so two inches of the joint are included. Direct the central ray perpendicular to the center of the film. Sandbags under toes or heel to maintain a true lateral position and under good leg for immobilization. ID is placed on the side or between the views. Measure through the center of the leg.

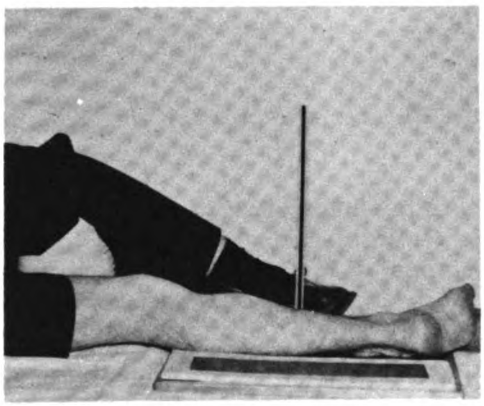
# THE KNEE

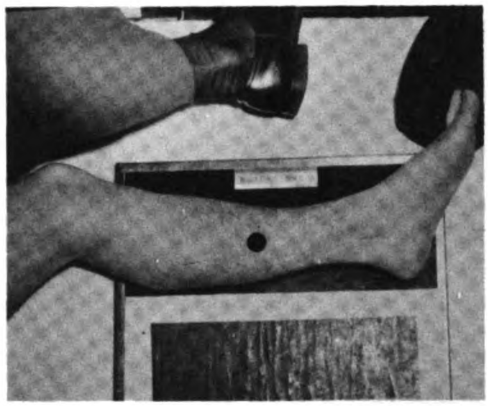
## POSTERIOR-ANTERIOR VIEW OF THE KNEE

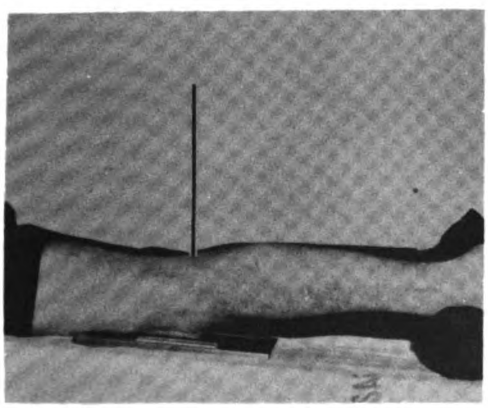
Use an 8 x 10 cassette placed lengthwise in the bucky tray. Place the patient in the prone position with sandbags under the ankles. Center the knee to the white line on the table. Center the film to a point one-half inch above the head of the fibula. Direct the central ray perpendicular to the center of the film. Place the ID on the side. Measure through the central ray.

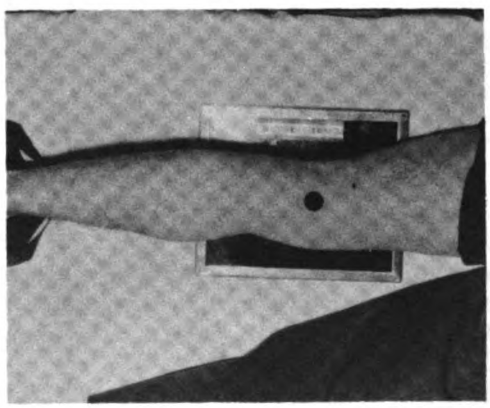












### LATERAL VIEW OF THE KNEE

Use an 8 x 10 cassette placed lengthwise in the bucky tray. Place the patient in the lateral recumbent position. Flex the good leg over the bad one. Have the patient bend his knee so that there is a 45 degree angle of the joint if possible. Align the femur to the midlength of the film so that the tibia and fibula pass through one corner of the film. Center the film to the base of the patella. Direct the central ray perpendicular to the center of the film. Sandbags under toes and flexed leg for immobilization. Measure the central ray.

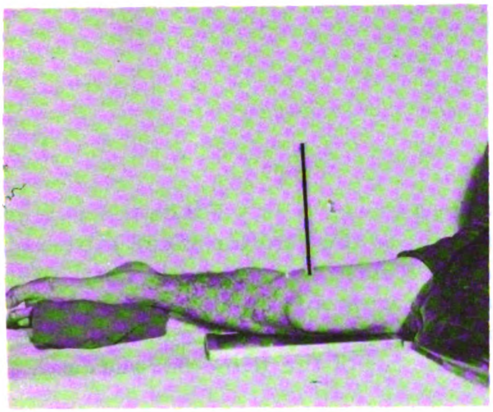
## THE FEMUR

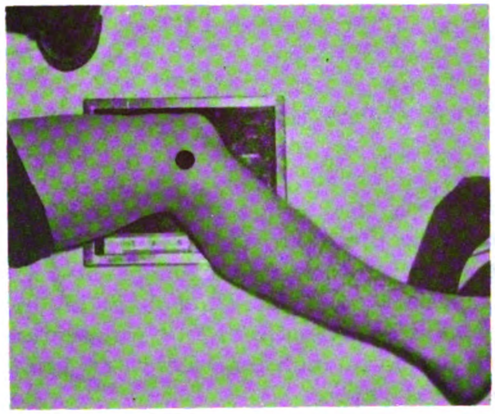
### ANTERIOR-POSTERIOR VIEW OF THE FEMUR (Lower two-thirds)

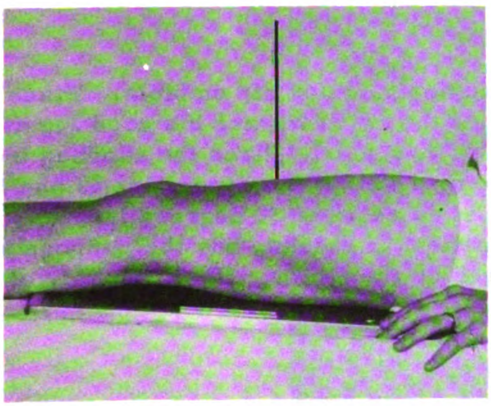
Use a 14 x 17 cassette placed lengthwise in the bucky tray. Place the patient in the supine position on the table. Center the femur to the white line on the table. The toes should be straight up if possible. Include at least two inches of the knee joint in the film. The central ray is directed perpendicular to the center of the film. Place sandbags on either side of the foot to maintain immobilization. The ID goes on the side. Measure through the central ray.

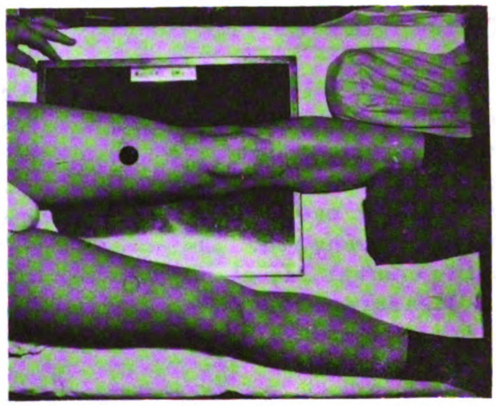
### LATERAL VIEW OF THE FEMUR

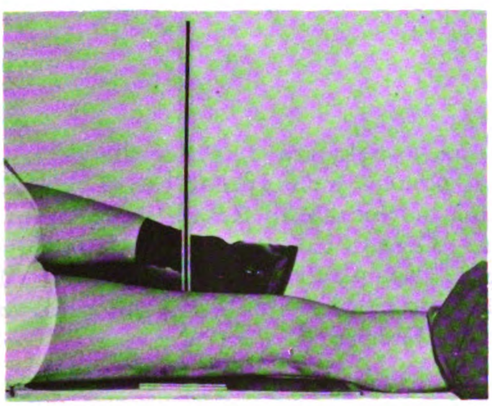
Use a 14 x 17 cassette placed lengthwise in the bucky tray. Place the patient in a lateral recumbent position on the table. Have the patient flex his good leg over the bad leg. Place sandbags under his flexed leg to support it. Align the femur to the white line on the table. Place a sandbag under the toes or heel to maintain a true lateral position. Include the knee joint on the film. Direct your central ray perpendicular to the center of the film. Measure your central ray. Place your ID on the side.

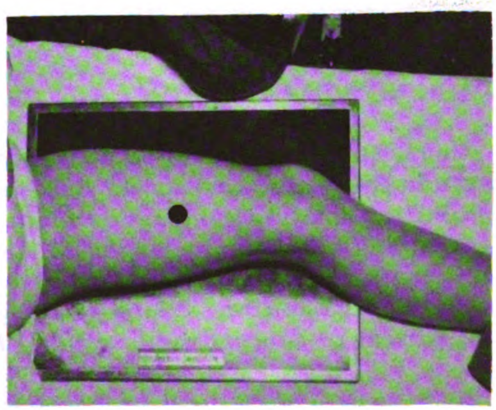












# THE HIP

## ANTERIOR-POSTERIOR VIEW OF THE HIP

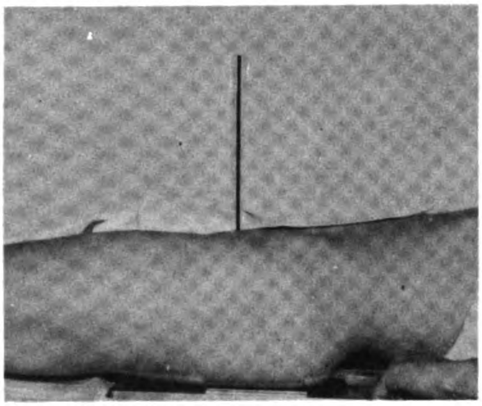
Use a 10 x 12 cassette placed lengthwise in a bucky tray. Place the patient on the table in the supine position. Center the hip joint to the midline of the table. Center the film to the level of the greater trochanter. Rotate the entire leg until the toes are straight up. Place sandbags on either side to immobilize the leg. Direct the central ray perpendicular to the center of the film. Use an extension cylinder and figure for a six-inch cone field. ID is burned at the top of the film. Measure through the central ray.

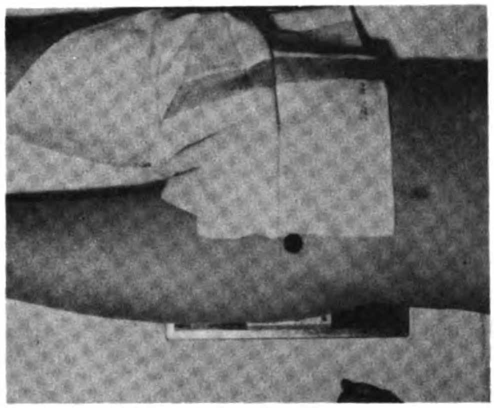
## LATERAL VIEW OF THE HIP

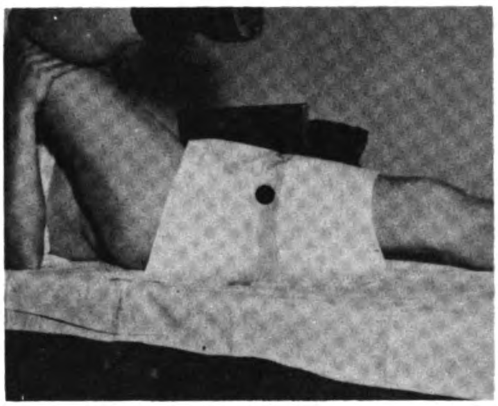
Use a 10 x 12 cassette placed lengthwise alongside of hip on table. Place the patient in the supine position on the table. Have the patient grasp his good leg at the knee and flexing at the knee and hip raise it off the table. Place the sandbag under knee and ankle to support this leg. Center the film so that the upper edge is one inch above the iliac crest. Direct the central ray at an angle of 30 degrees laterally and 25 degrees downward. This may vary from patient to patient, but the purpose is to pass the central ray at right angles to the neck of the femur. ID on top side of the film. Measure through the central ray.

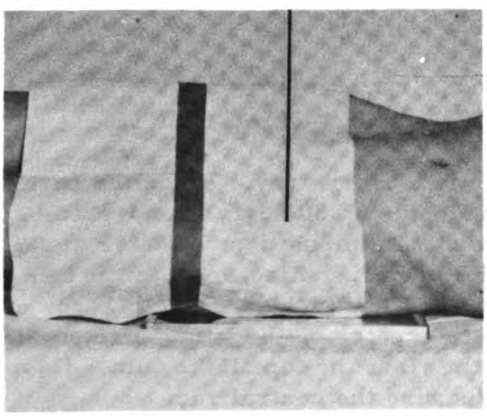
## OBLIQUE VIEW OF THE HIP

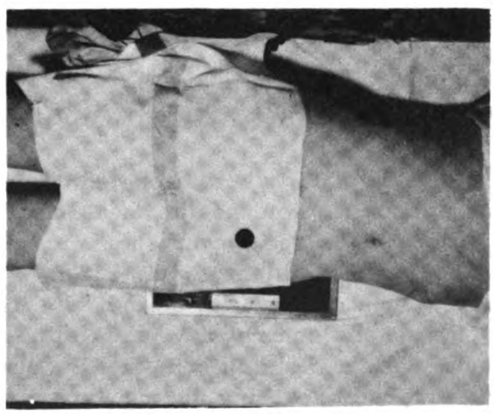
Use a 10 x 12 cassette placed lengthwise in a bucky tray. Place the patient on the table in the supine position so that a sagittal plane 2 inches medial to the anterior superior iliac spine is centered to the white line on the table. Rotate the body of the patient toward the bad side about 30 degrees. Center the film at the level of the greater trochanter. Direct the central ray perpendicular to the center of the film. ID on the side of the film. Place sandbags under the thighs, small of back and shoulders of patient to support the position. Measure through the central ray.











## THE PELVIS

### ANTERIOR-POSTERIOR VIEW OF THE PELVIS

Use a 14 x 17 cassette placed lengthwise in a bucky tray. Place the patient in a supine position. The median plane is centered to the center of the table. The film is placed so the upper edge is 2 inches above the iliac crest. The toes are rotated slightly internally to maintain a true AP position. Place sandbags on either side of the feet. Direct the central ray perpendicular to the median plane midway between the symphysis pubis and the anterior-superior iliac spines. Have patient suspend breathing after inhalation, then make exposure. Place the ID on the top above the iliac crest. Measure through the central ray.

## THE SYMPHYSIS PUBIS

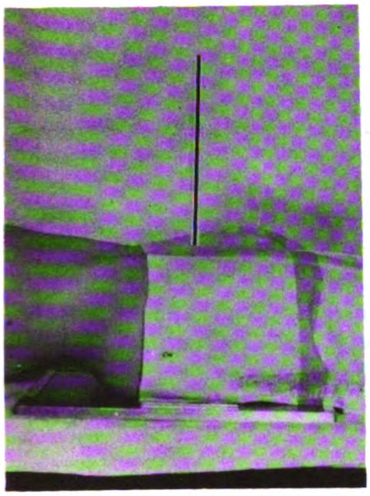
### POSTERIOR-ANTERIOR VIEW OF THE SYMPHYSIS PUBIS

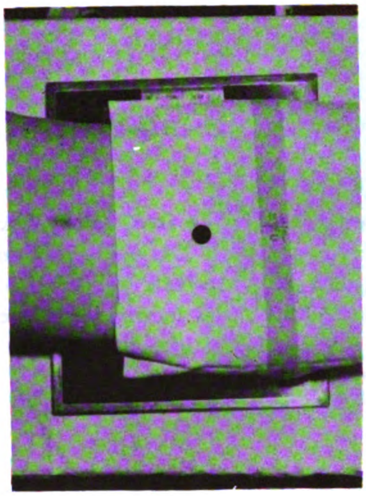
Use a 10 x 12 cassette placed crosswise in a bucky tray. Place the patient in the prone position. Center the median plane of the body to the white line of the table. Center the film to the level of the greater trochanter. Direct the central ray at an angle of 15 degrees toward the head. It will enter the tip of the coccyx. The ID is placed at the bottom center of the film. Place sandbags under the ankles. Measure through the central ray.

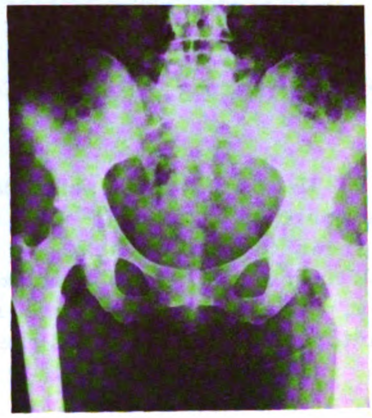
## THE SACRO-ILIAC JOINTS

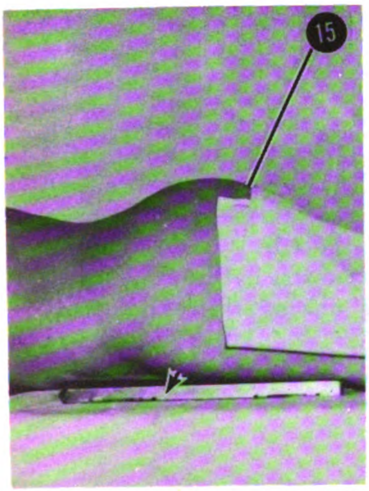
### ANTERIOR-POSTERIOR OBLIQUE VIEW OF THE SACRO-ILIAC JOINTS

Use a 10 x 12 cassette placed lengthwise in a bucky tray. Place the patient in the supine position on the table. Rotate the bad side up 30 degrees and place sandbags under thighs and lower thoracic spine to maintain position. Center a sagittal plane that passes 2 inches medial to the anterior-superior iliac spine to the center of the table. Center the film so that the iliac crest is one inch above the center of the film. Direct the central ray perpendicular to the center of the film. Use an extension cone with a six-inch cone field. Burn in the ID at the top of the film. Have the patient suspend breathing during exposure. Measure the central ray.





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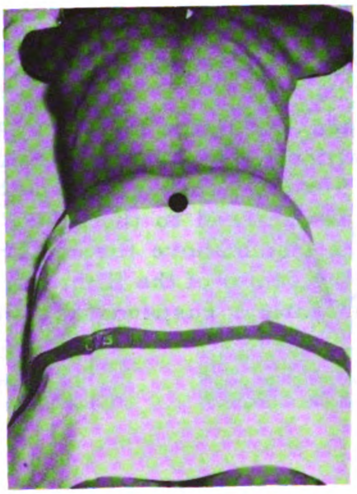
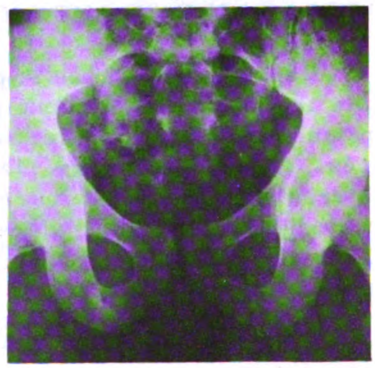
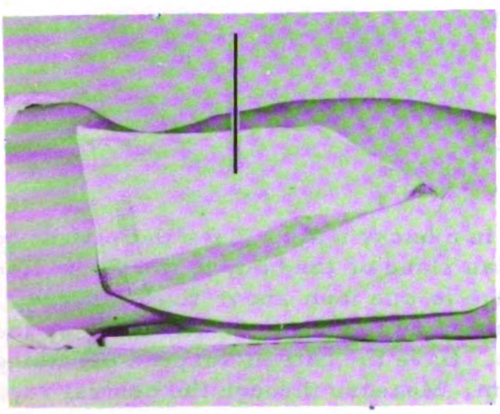
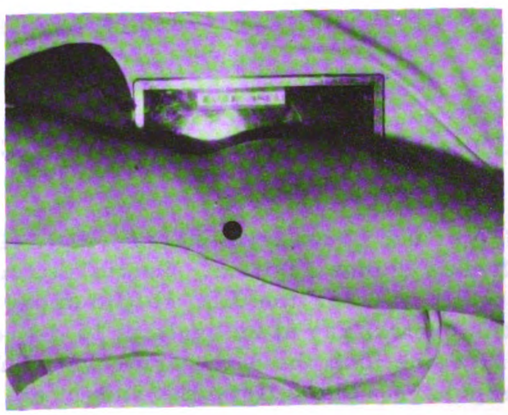








# THE LUMBO-SACRAL JOINT

## ANTERIOR-POSTERIOR VIEW OF THE LUMBO-SACRAL JOINT

Use an 8 x 10 cassette placed lengthwise in a bucky tray. Have the patient assume the position for the AP view of the pelvis. Direct the central ray at an angle of 25 degrees toward the head. It enters the median plane at a point about one and one-half inches below the iliac crest. The film is centered to coincide with the central ray. An extension cylinder is used with a six-inch cone field. ID is burned in at the top. Measure through the central ray.

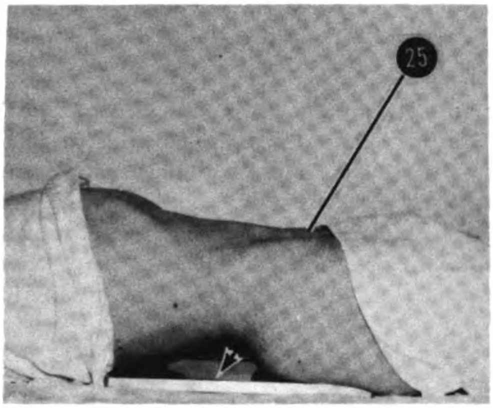
## LATERAL VIEW OF THE LUMBO-SACRAL JOINT

Use an 8 x 10 cassette placed lengthwise in a bucky tray. Have the patient assume the lateral recumbent position. The arms are folded about the head and the hips and knees are together and flexed. Sandbags are placed between the ankles and knees. The mid-axillary plane is centered to the center of the table. The film is centered so that the iliac crest is 1 inch above the center of the film. The central ray is directed perpendicular to the center of the film. An extension cylinder is used with a six-inch cone field. The patient suspends breathing during the exposure. Measure the central ray.

# THE SACRUM

## ANTERIOR-POSTERIOR VIEW OF THE SACRUM

Use a 10 x 12 cassette placed lengthwise in a bucky tray. Place the patient on the table in a supine position. Center the median plane of the body to the white line on the table. Center the film so the upper edge is one inch above the iliac crest. Direct the central ray at an angle of 15 degrees toward the head. It will enter on the median line one inch above the symphysis pubis. Have the patient suspend breathing during exposure. Place ID on the side of the film. Measure through the central ray.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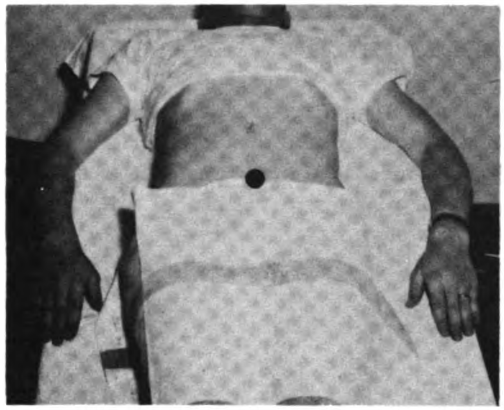

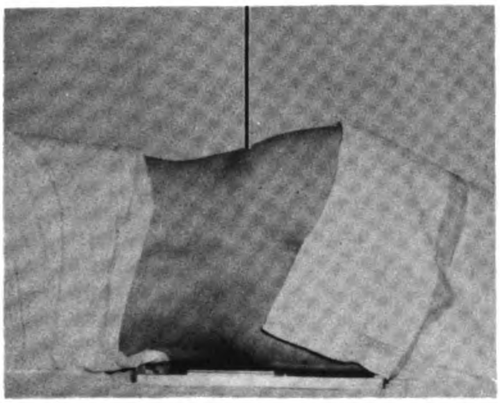

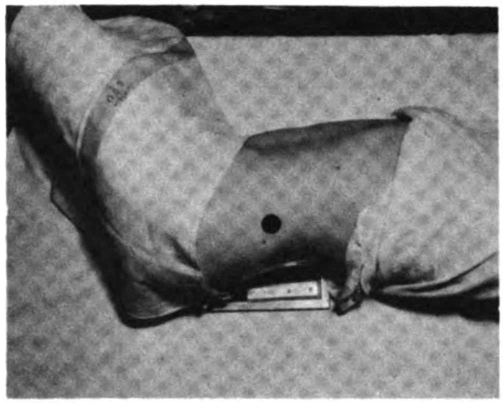

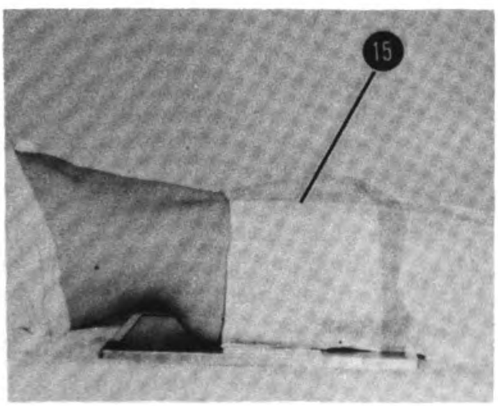
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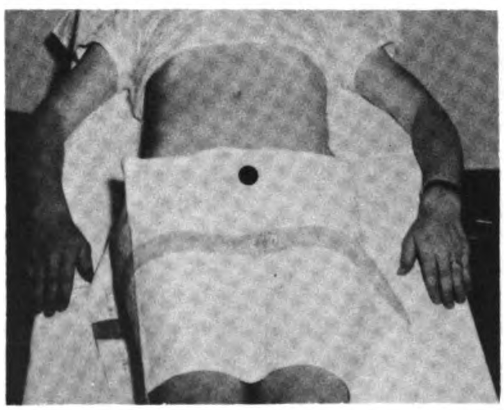


### LATERAL VIEW OF THE SACRUM

Use a 10 x 12 cassette placed lengthwise in a bucky tray. Place the patient in a lateral recumbent position. His arms should be folded under his head and his knees and hips flexed. Sandbags are placed between ankles and knees. Center the mid-axillary plane to the center of the film. Direct the central ray perpendicular. It will enter at a point 2 inches from the back skin surface. You can feel the sacrum in the back. The film is centered so the upper edge is one inch above the iliac crest. Have patient suspend breathing during the exposure. ID goes on the posterior side. Measure through the central ray.

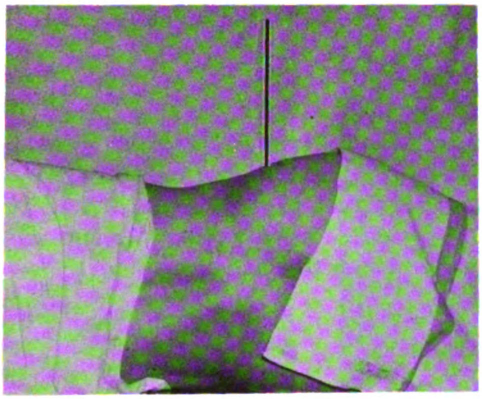
## THE LUMBAR SPINE

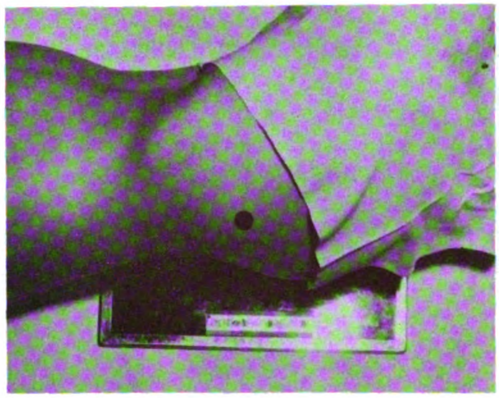
### ANTERIOR-POSTERIOR VIEW OF THE LUMBAR SPINE

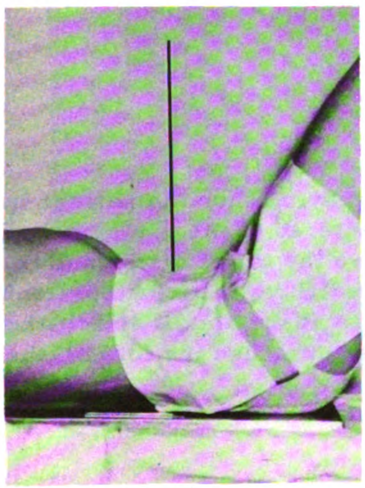
Use a 14 x 17 cassette placed lengthwise in a bucky tray. Place the patient in the supine position on the table. Center the median plane of the body to the white line of the table. Place pillows beneath the shoulders and have the patient flex his knees. This will minimize the lumbar curve. The film is centered so that the iliac crest is one inch above the center of the film. The central ray is directed to the third lumbar vertebra and is perpendicular. Suspend the patient's breathing after inhalation during the exposure. Place the ID on the side. Measure through the third lumbar vertebra region with respiration suspended.

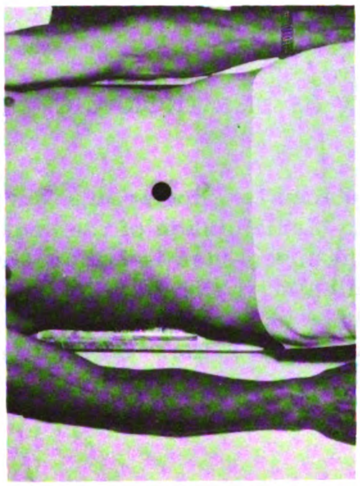
### LATERAL VIEW OF THE LUMBAR SPINE

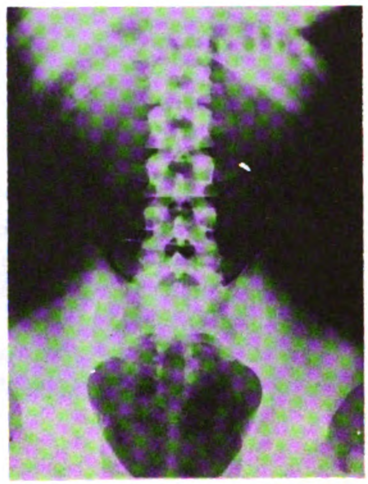
Use a 14 x 17 cassette placed lengthwise in a bucky tray. Place the patient in the lateral recumbent position on the table. Center the mid-axillary plane to the white line of the table. Have the patient fold his arms about his head and flex the hips and knees. Place sandbags between the ankles and knees. Place a rolled towel under the small of the back just above the iliac crest. If no pad is used angle the CR 10 to 15 degrees. This is to compensate for the natural curve of the back seen in the lateral position. Center the film so the iliac crest is one inch above the center of it. Direct the central ray perpendicular to the film at a point on the mid-axillary plane just over the center of the film. Have patient hold breath after inhalation during the exposure. ID goes on posterior side. Measure through the central ray.

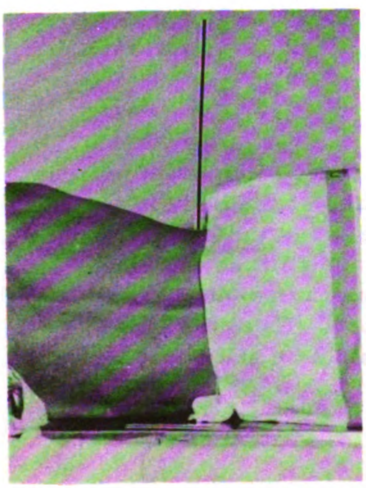


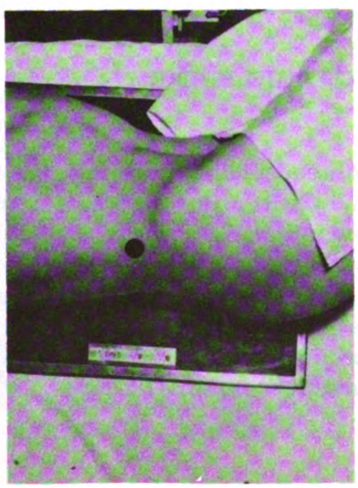












## OBLIQUE VIEW OF THE LUMBAR SPINE

Use a 14 x 17 cassette placed lengthwise in a bucky tray. Have the patient assume the position for the AP. Rotate the body up 45 degrees and center spine over white line of table. Place sandbags under shoulders and hips to maintain position. Central ray is perpendicular. Film centered as in AP. Respiration suspended after inhalation. The ID and measurement are the same as in the AP view.

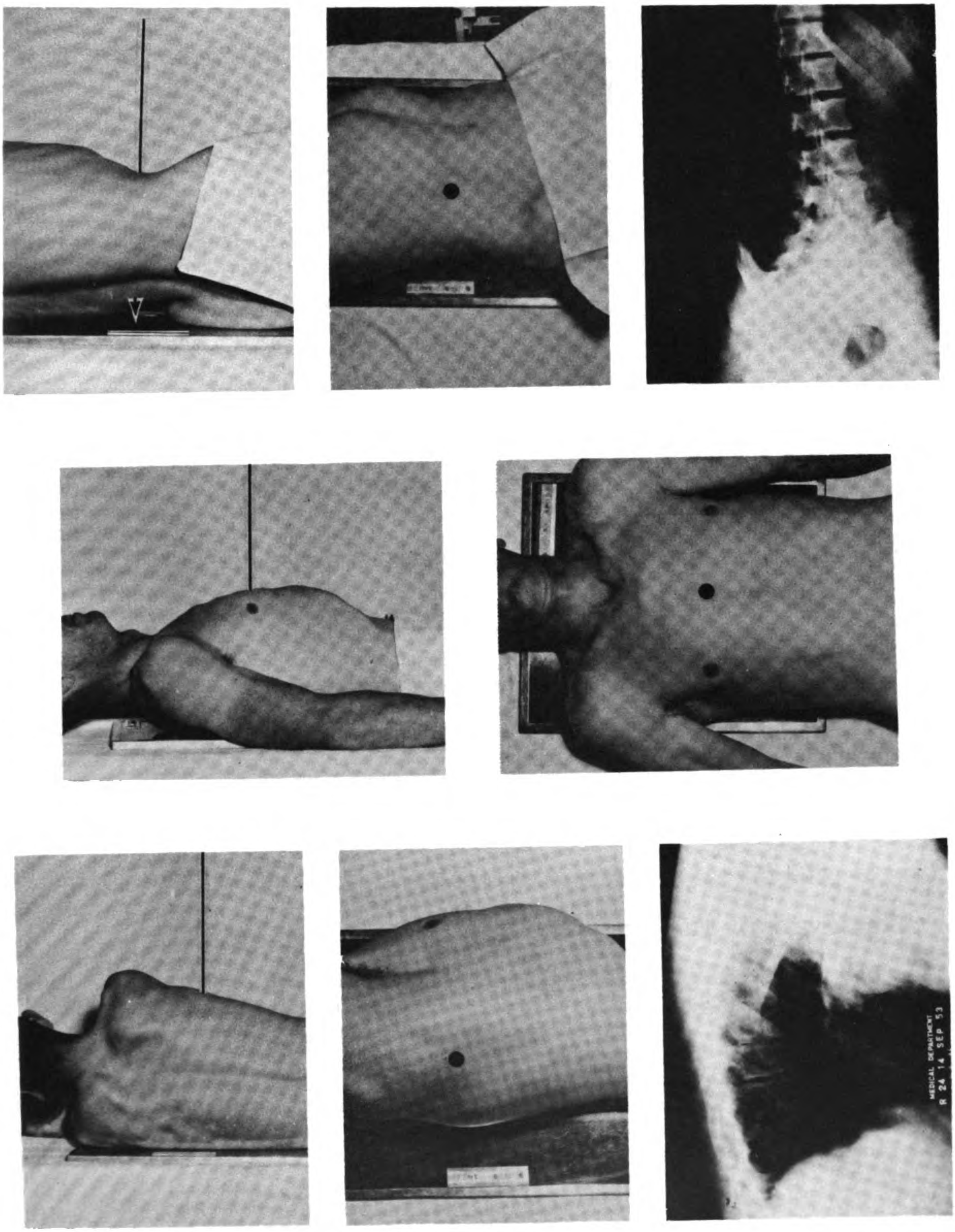
# THE THORACIC SPINE

## ANTERIOR-POSTERIOR VIEW OF THE THORACIC SPINE

Use a 14 x 17 cassette placed lengthwise in a bucky tray. Place the patient in a supine position on the table. Median plane of the body centered to the white line on the table. Place the film so the upper edge is 2 inches above the top of the shoulder. Direct the central ray perpendicular to the sixth thoracic vertebra. Have the patient suspend respiration after inhalation during the exposure. Place the ID above the shoulder. Measure through the nipple line. On female patients, use the fold of the axilla as a guide to the sixth thoracic vertebra.

## LATERAL VIEW OF THE THORACIC SPINE

Use a 14 x 17 cassette placed lengthwise in a bucky tray. Place the patient in the lateral recumbent position. Center the mid-axillary plane of the body to the white line on the table. The arms are folded over the head and the knees and hips are flexed. Sandbags are placed between ankles and the knees. Place the film so the upper edge is 2 inches above the top of the shoulder. Direct the central ray perpendicular to the mid-axillary plane at the level of the sixth thoracic vertebra. Have the patient suspend breathing after inhalation during the exposure. ID is put on the posterior side. Measure through the sixth thoracic vertebra.


MEDICAL DEPARTMENT
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## OBLIQUE VIEW OF THE THORACIC SPINE

Use a 14 x 17 cassette placed lengthwise in a bucky tray. Have your patient assume the basic AP position. Rotate the body up about 30 degrees and place sandbags under thighs and small of back. The arm grasps the edge of the table to hold upper part of the body or a sandbag is used at the edge of the shoulder. All other steps are the same as the AP. Be sure to center the spine to the table, however.

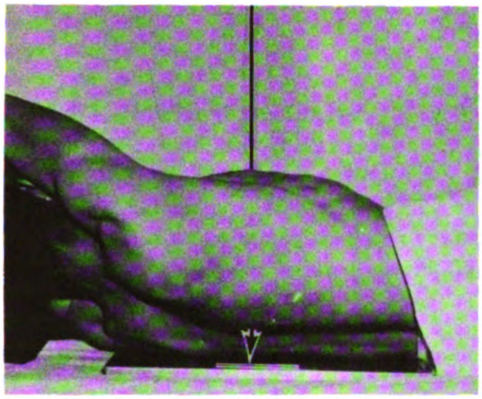
# THE CERVICAL SPINE

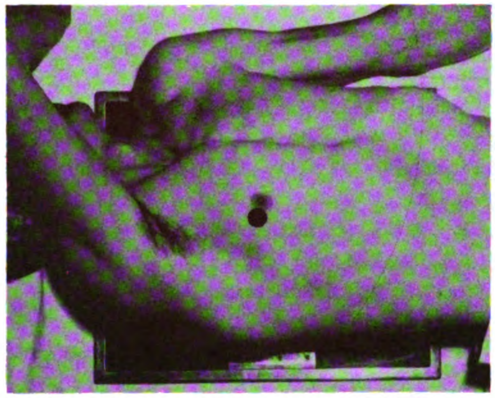
## ANTERIOR-POSTERIOR VIEW OF THE CERVICAL SPINE

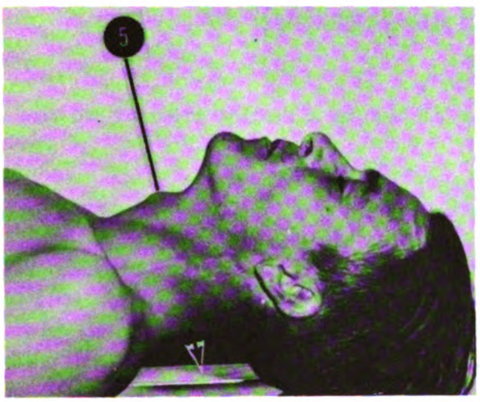
Use an 8 x 10 cassette placed lengthwise in a bucky tray. Place the patient in a supine position. Median plane of body centered to the table. Extend the patient's chin slightly. Center the film to the level of the fourth cervical vertebra. This lies under the thyroid cartilage or "Adams apple". Direct the central ray at an angle of 5 degrees toward the head to the fourth cervical vertebra. Have patient suspend respiration during exposure. ID goes on the side. Measure through the path of the central ray.

## LATERAL VIEW OF THE CERVICAL SPINE

Use an 8 x 10 cassette placed lengthwise in a vertical cassette holder. This view is taken at 72 inches because of the great amount of part-film distance. Place the patient in the lateral erect position. Center the coronal plane to the center of the film. Extend the chin until the angles of the mandible are free of the top cervical vertebra. Center the film to the level of the thyroid cartilage (fourth cervical). Direct central ray horizontally through the coronal plane at the level of the fourth cervical vertebra. The patient suspends his breathing during the exposure. Place ID on the anterior side. Measure through the thyroid cartilage.



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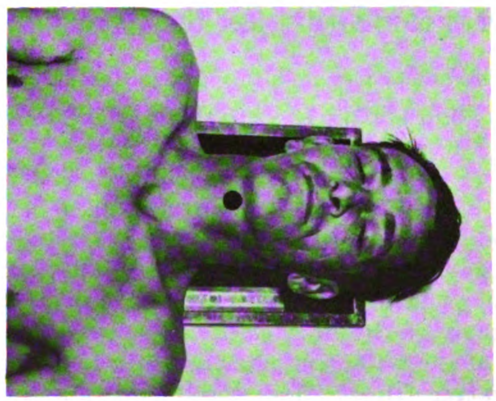
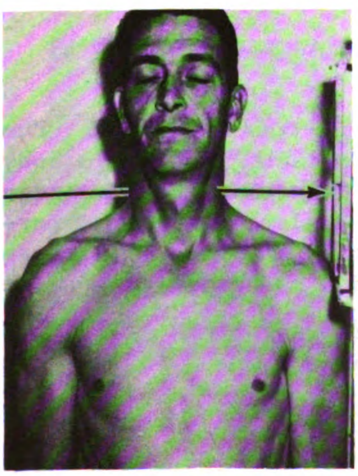
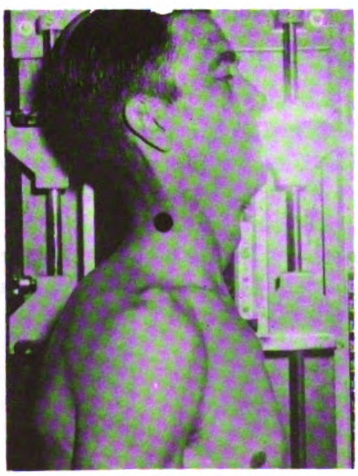






## OBLIQUE VIEW OF THE CERVICAL SPINE

Use an 8 x 10 cassette placed lengthwise in a vertical cassette holder. Place patient in an erect position with front facing tube. In this position the side away from the film will be shown on the film. Rotate the side under study 45 degrees from the film. Center the spine to the mid-length of the film. Direct your central ray horizontally to the film through the level of the fourth cervical vertebra. Have patient suspend respiration during exposure. Place ID on one side clear of part. Measure through the central ray.

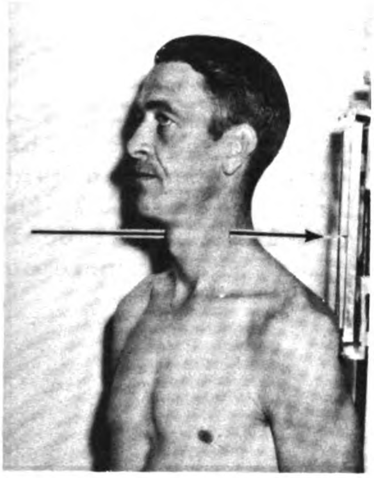
# THE STERNUM

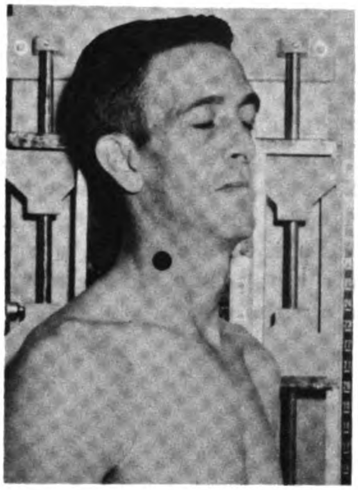
## POSTERIOR-ANTERIOR OBLIQUE VIEW OF THE STERNUM

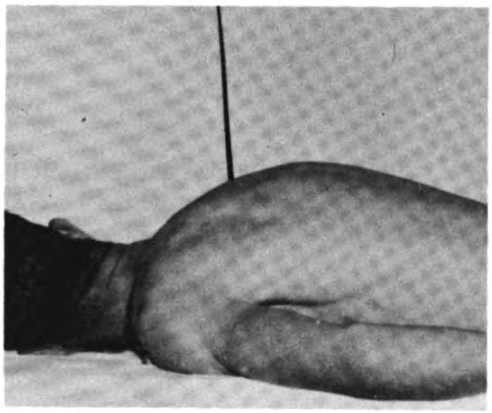
Use a 10 x 12 cassette placed lengthwise either in a bucky tray or on the table top.

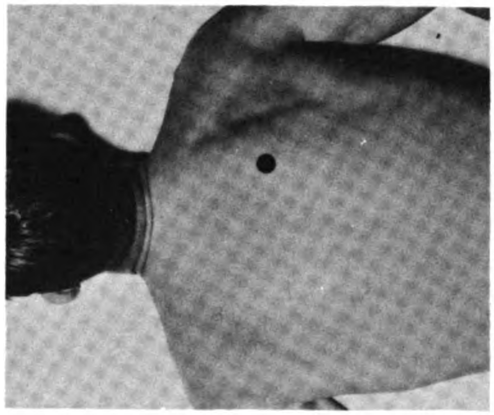
TUBE ANGULATION METHOD. Center lengthwise film to the center of the table. Place the patient in the prone position. Line up the film to the sternum. Have the upper edge of the film 2 inches above the manubrial notch. Direct the central ray 3 inches lateral to the fifth thoracic vertebra and then angle it so that it will come out through the body of the sternum. (This localization is usually done from the right side of the body, but the left side is sometimes used so that the heart can act as compensating filter. Because the sternum is thinner at the bottom than at the top the heart will add density to the thinner bottom area and provide you with a more even density along the entire sternum). Have patient suspend respiration during the exposure. Place ID on one side. Measure through the central ray.

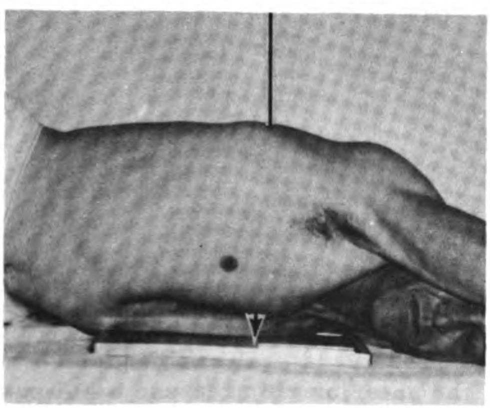
BODY ROTATION METHOD. Place the film in a bucky tray lengthwise. The patient is prone and sternum is lined to the white line on the table. Rotate the body so the right side is up and forms an angle of 30 degrees to the table. The upper edge of the film is 2 inches above the manubrial notch. The central ray is directed perpendicular to the film at the level of the fifth thoracic vertebra. Have the patient suspend respiration during exposure. Place the ID on the side. Measure through the central ray.

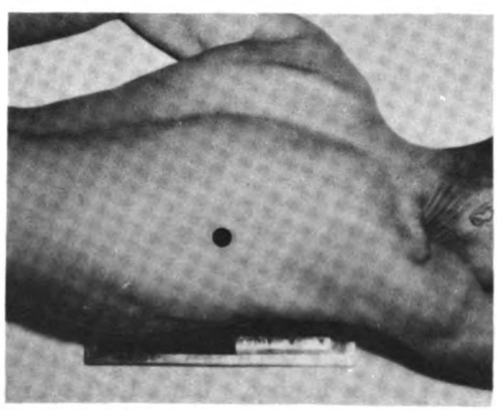












**SHALLOW BREATHING TECHNIQUE OR SHORT - FOCAL - FILM DISTANCE TECHNIQUE.** Shallow breathing sometimes is used to blur the rib shadows. This movement is practiced a little before the exposure by the patient so that he doesn't breathe too deeply. Your exposure must be made at a longer time. This allows the chest to move enough to produce the blurring of the ribs. The use of a short focal-film distance also blurs out the ribs. The closer the tube is to the part the more out of focus are areas far away from the film.

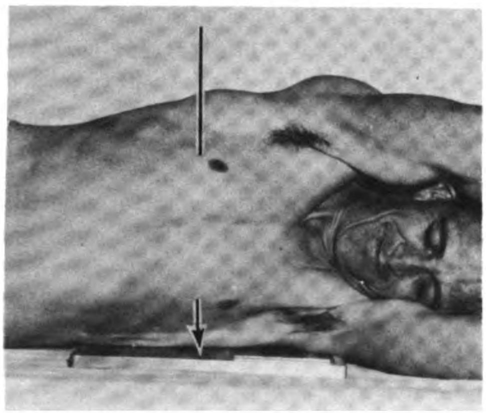
## LATERAL VIEW OF THE STERNUM

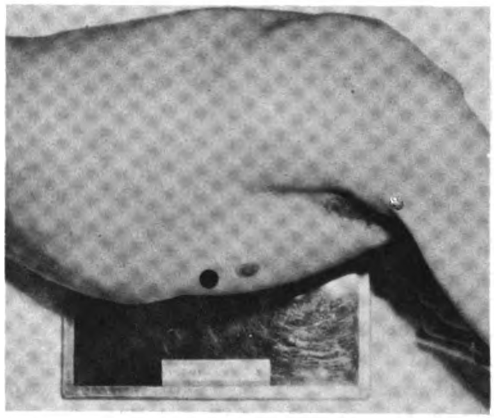
Use a 10 x 12 cassette placed lengthwise in the table. Place the patient in the lateral recumbent position on the table. Center the sternum to the white line on the table. Place the film so the upper border is 2 inches above the manubrial notch. Direct the central ray perpendicular one inch below the sternal angle. Have patient suspend breathing after inhalation during exposure. ID on side. Measure CR.

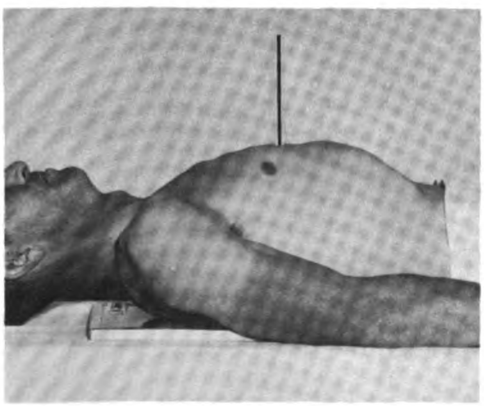
# THE RIBS

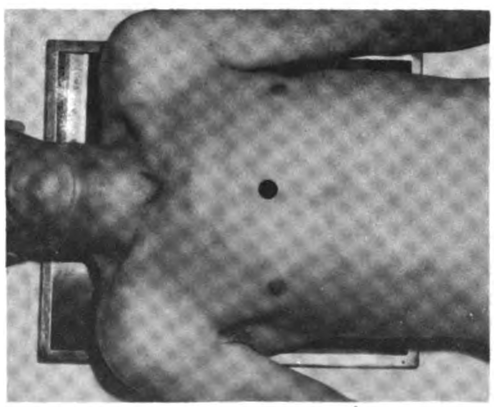
## ABOVE THE DIAPHRAGM

Use the appropriate size of film, usually a 14 x 17 cassette. Always center the film to the SITE OF INJURY. ALWAYS PLACE THE SITE OF INJURY NEXT TO THE FILM. The film is placed lengthwise in a vertical cassette holder. The central ray is directed horizontally to the site of injury. Have patient suspend breathing, after maximum inhalation, during the exposure. Leave this up to the patient, but have him try to get the maximum. ID placed on any free side so it doesn't get into the area of injury. Measure through the central ray. (This examination is also done in the recumbent position. The positions can be PA, AP, lateral or oblique depending upon the side of injury. Usually fractures of the anterior rib area use a PA position because you get the part closer to the film. The other positions are used for the same reason).









## THE RIBS

### BELOW THE DIAPHRAGM

Use a 14 x 17 cassette placed crosswise in the bucky tray. The patient is supine in either an AP or oblique position. This is because of the location and structure of those ribs below the diaphragm. All of the other procedures are the same.

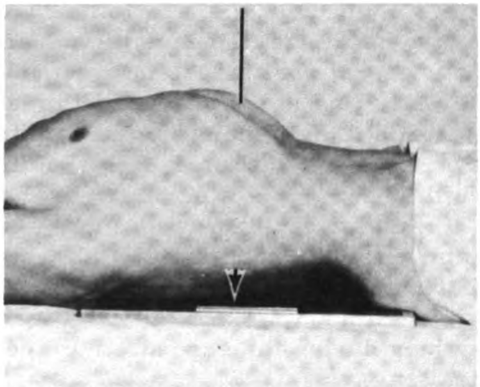
## THE SKULL

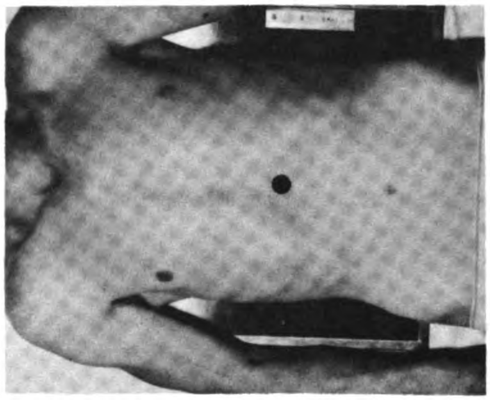
### POSTERIOR-ANTERIOR VIEW OF THE SKULL

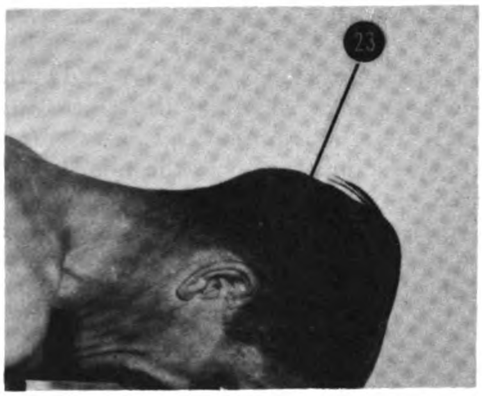
Use a 10 x 12 cassette placed lengthwise in a bucky tray. The patient is placed in the prone position with the arms folded under his chest. The median plane of the body and head is centered to the white line on the table. The head is placed so that it rests on the forehead and nose. The film is centered to the nasion (Nasion: point where nasal and frontal bones meet). The central ray is angled 23 degrees toward the feet. It enters a point two and one-half inches above the EOP (external occipital protuberance) and comes out at the nasion. Have the patient suspend breathing during the exposure. Place the ID to one side. Measure through the central ray. Be sure that the body is lined up with the head. If it isn't it can make your skull position inaccurate. (Angulation of the central ray is varied. Some clinics will use 12, 15, 17, or 23 degrees. The angulation will affect the type of radiograph you will demonstrate so it is important that you study your radiographs so you can see what effect it will have on the structures of the skull).

### ANTERIOR-POSTERIOR VIEW OF THE SKULL

Use a 10 x 12 cassette placed lengthwise in a bucky tray. The patient is placed in the supine position on the table. The median plane of the head and body is centered to the white line on the table. The chin is pulled down on the chest until the orbitomeatal line is perpendicular to the film. (Orbitomeatal line: an imaginary line that runs from the EAM or external auditory meatus to the external canthus of the eye. The external canthus of your eye is the point where the skin of the eye comes together on the lateral side of the eye). The film is centered to the nasion. The central ray is directed perpendicular to the nasion. Have the patient suspend breathing during exposure. Place the ID on one side. Measure through the central ray.



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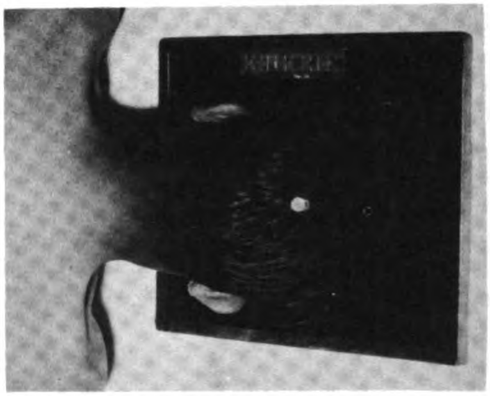


## LATERAL VIEW OF THE SKULL

Use a 10 x 12 cassette placed crosswise in a bucky tray. Place the patient in a prone position. Have him place his head in a lateral position so injured side is placed next to the table. Place the EAM on the white line in the center of the table. Have the patient place his fist under the tip of his chin to help maintain a true lateral position. Check the interpupillary line and make sure it is vertical. (Interpupillary line: A line that passes through the pupils when the eyes are looking straight ahead). Check the median plane of the head and see if it is parallel to the table top. Center the film so the upper edge is at least one inch above the top of the skull. Direct the central ray perpendicular. It will enter at a point one inch above the EAM and one and one-half inches anterior to the EAM. This should place it over the sella turcica of the sphenoid bone. Have patient suspend breathing during the exposure. Place the ID on the face side. Measure through the central ray.

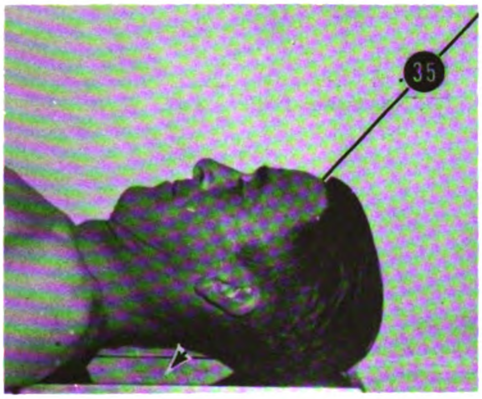
## FRONTO-OCCIPITAL VIEW OF THE SKULL (TOWNE'S)

Use a 10 x 12 cassette placed lengthwise in the bucky tray. The patient is placed in the supine position. Median plane of body and head is centered to the white line on the table. The chin is pulled down on the chest. The orbitomeatal line is vertical to the table. The film is placed so the upper edge is right at top of the head. Direct the central ray at an angle of 35 degrees. It will enter at a point 3 inches above the glabella (the area on the frontal bone just between the eyes above the nasion) and come out at the base of the mastoid processes. Have patient suspend breathing during the exposure. Place the ID on the side. Measure the central ray.

## THE SUBMENTOVERTEX VIEW OF THE SKULL

(Means from below the mandible, "submento"; to the top of the head, "vertex".)

Use a 10 x 12 cassette placed lengthwise in a bucky tray. Place the patient in the supine position. Place pillows under shoulders until the head can be extended as far back as possible. Have the patient extend his head back until the top of the skull touches the table and the orbitomeatal line is parallel to the table. Be certain that the median plane of the body and head is vertical to the table. Center the film to the top or vertex of the head. Direct the central ray perpendicular to the film. It should enter midway between the angles of the mandible and strike the orbitomeatal line at right angles. Have patient suspend breathing during the exposure. Place the ID on the side. Measure through the central ray.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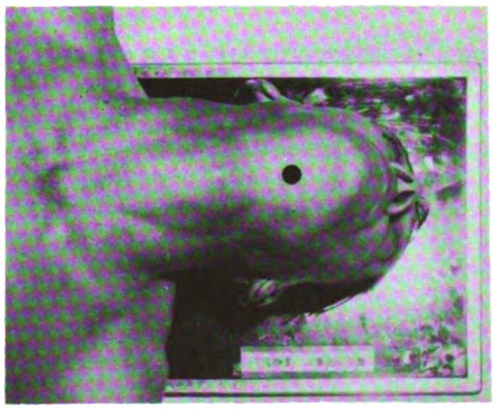


### THE LATERAL OBLIQUE VIEW OF THE SKULL

Use a 10 x 12 cassette placed crosswise in the bucky tray. Place the patient in the lateral skull position. All steps are approximately the same with the exception of the central ray. The central ray is angled 30 degrees toward the feet. It enters 3 inches above the EAM farthest from the film and comes out one inch below the EAM nearest the film. The upper edge of the film is placed right at the top of the skull. The ID is on the face side.

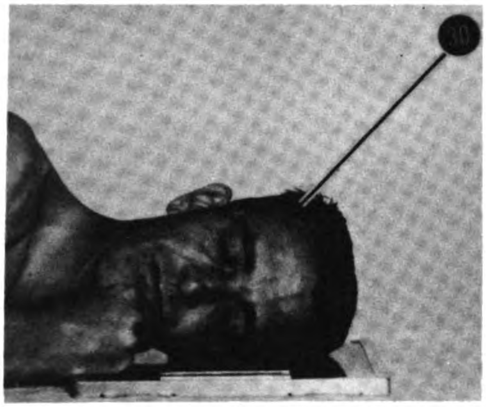
## THE PARANASAL SINUSES

### CALDWELL'S POSITION (Frontals - also known as nose-forehead)

Use an 8 x 10 cassette placed lengthwise. (Some clinics use buckys and others use a non-bucky technique). This position is the same as the PA view of the skull with the addition of the extension cylinder with a six-inch cone field. Burn in ID at the top of film. (This position can be done either erect or in the prone position. The position will depend upon what the radiologist prefers. Generally, it will be erect because this position will allow for the demonstration of the fluid level).

### WATER'S POSITION OF PARANASAL SINUSES (Maxillary - also known as nose-chin)

Use an 8 x 10 cassette placed lengthwise. Bucky or table top technique can be used. Place the patient in a prone position or a PA position. The median plane of head and body is perpendicular to the film. The nose is raised off the film one inch. The film is centered to the nasolabial junction. (Nasolabial junction is a point where the nose and lip meet). The central ray is perpendicular to the center of the film. It enters the posterior surface of the head and comes out at the nasolabial junction. The patient suspends breathing during the exposure. ID is burned in at top. Use a cone with six-inch cone field. Measure through the central ray. (The raised nose drops the petrous pyramids of the temporal bone out of the maxillary sinuses).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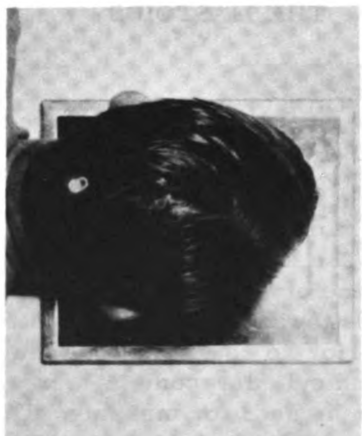

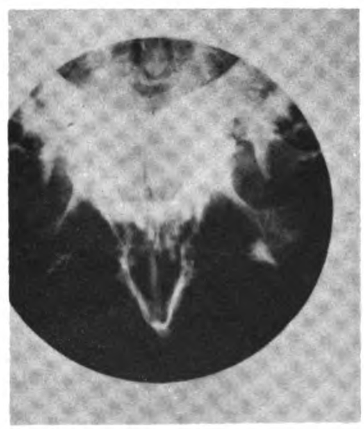

## LATERAL VIEW OF THE PARANASAL SINUSES

Use an 8 x 10 cassette placed lengthwise. This view is to obtain all of the paranasal sinuses in one view. It is the same basic position as the lateral skull with the following exceptions: The film is centered to the external canthus of the eye. The central ray is perpendicular to the external canthus of the eye. The ID is burned in at the top of the film.

## VERTICOSUBMENTAL VIEW (Sphenoid sinus)

Use an 8 x 10 cassette placed lengthwise. The chin is extended out over the film as far as possible. The patient is seated or in a prone position. The film is centered to the point between the angles of the mandible and the mental symphysis. The median plane of the head and body is perpendicular to the film. The orbitomeatal line is parallel to the film. The central ray is directed from the top of the head to the film so that it strikes the orbitomeatal line at right angles. The patient suspends respiration during exposure. The ID is burned in at the top because a cylinder cone is used on this view, too. You will figure a six-inch cone field. Measure through the central ray.

# THE MASTOIDS

## LATERAL VIEW OF THE MASTOIDS

Use 8 x 10 cassette placed crosswise. Lead masks are used so that both mastoids can be taken on the same film. Patient is placed in the prone position with his arms folded under his chest. The EAM of the affected side is centered on the film which is unmasked. Median plane of the skull is angled 15 degrees toward the face. Central ray is angled 15 degrees toward the feet. It enters a point two inches above the EAM and two inches posterior to the EAM. It comes out through the mastoid nearest the film. Use extension cylinder cone or a mastoid board. A lead rubber sheeting with one round hole can be used for masking. Tape ears forward so they do not cover the delicate air cells of the mastoids. Patient suspends breathing during the exposure. ID is at the top. Get the right markers on the film. Measure through the CR.


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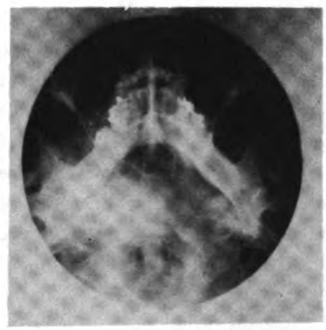


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## ANTERIOR-POSTERIOR VIEW OF THE MASTOIDS

Use an 8 x 10 cassette crosswise. Lead masks are used. Take both mastoids. Place the patient in the supine position. The median plane of the head is rotated 30 degrees, with the affected mastoid being turned up. The tip of the mastoid is centered to the center of the film. The central ray is angled 17 degrees toward the feet. It enters a point one-half inch above the EAM and comes out at the base of the mastoid process. Burn in the ID at the top of the film. Suspend patient's breathing during the exposure. Measure through the central ray.

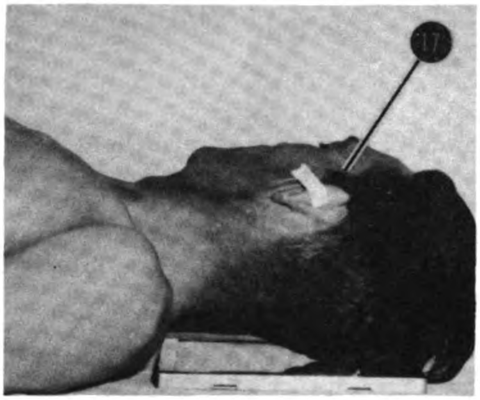
## POSTERIOR-ANTERIOR VIEW OF THE ' STOIDS

Use an 8 x 10 cassette crosswise. Lead masks are used. Take both mastoids. Place the patient in the prone position. The head rests on the forehead, nose and cheek. Center the film to the EAM nearest the film. The central ray is angled 10 degrees toward the head. It enters the EOP and comes out at the top of the mastoid process. The median plane of the head is angled 45 degrees to the film. The patient suspends breathing during the exposure. Burn the ID in at the top of the film. Measure through the central ray.

# THE MANDIBLE

## LATERAL VIEW OF THE MANDIBLE

Use an 8 x 10 cassette placed crosswise on the table. The patient is prone. The film is built on the angle board or sandbags so that bottom edge of the cassette is angled 15 degrees from the table. The patient extends his chin and places the angle of the mandible over the raised edge of the film so it is in the center. The median plane of the head is rotated about 15 degrees toward the face. The central ray is angled 15 degrees toward the head. It enters the part two inches below the angle of the mandible away from the film and comes out through the body of the mandible next to the film. The patient suspends respiration during the exposure. The ID is either burned in if a cone field is used, or on the face side of the film. Measure through the central ray. (This examination can be made in the erect position in instances where there is a great deal of pain or the pressure of lying on the part would cause pain.)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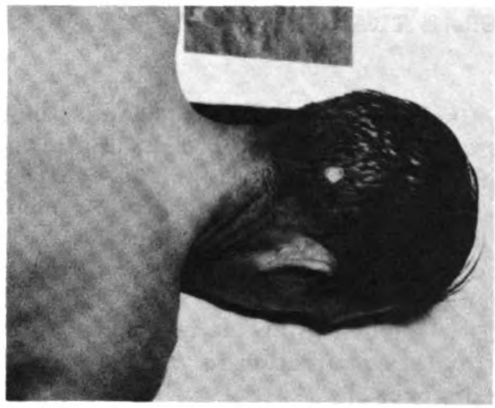


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## POSTERIOR-ANTERIOR VIEW OF THE MANDIBLE

Use an 8 x 10 cassette placed lengthwise in a vertical cassette holder. Two exposures are taken - one with the mouth closed and one with mouth open. The patient is in the PA erect position. The nose and forehead are against the film. The median plane of the skull is perpendicular to the film. The central ray is directed horizontally to the center of the film. The mental symphysis of the mandible is centered to the center of the film. Patient suspends breathing during exposure. The ID goes on the side. Measure the central ray.

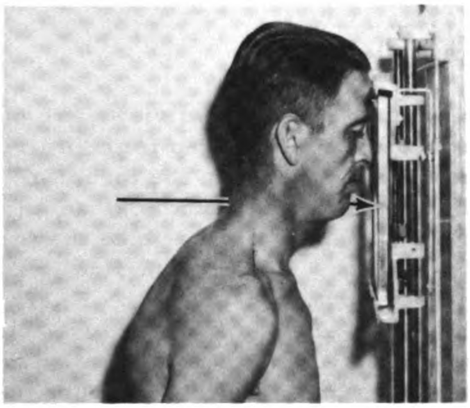
## THE TEMPOROMANDIBULAR ARTICULATION

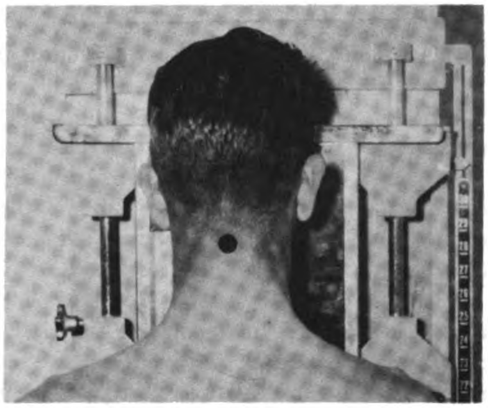
## LATERAL TRANSCRANIAL VIEW OF THE TEMPOROMANDIBULAR ARTICULATION

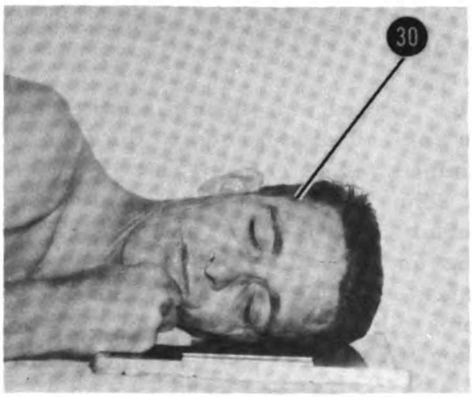
Use an 8 x 10 cassette placed crosswise. Lead masks are used because two views are required in this examination - one with the mouth open and one with the mouth closed. Some clinics will require that both articulations be taken for comparison. The patient assumes the basic position of the lateral skull position. The EAM is centered to the center of the film. The central ray is directed at an angle of 30 degrees toward the feet. It enters a point three inches above the EAM and comes out through the joint next to the film. The patient suspends breathing during the exposure. The ID is burned in at the top. Measure the central ray. (The degree of angulation used for this projection is varied. You may use, in various clinics, 20, 25, 30, 33 or 35 degrees.)

## LATERAL TRANSFACIAL VIEW OF THE TEMPOROMANDIBULAR ARTICULATION

Use same film and method as for transcranial view. The patient is placed in the supine position with the head in a lateral position. The EAM is centered to the center of the film. The central ray is directed 25 degrees toward the head. It enters below the angle of the mandible above the film and comes out through the joint on the film.



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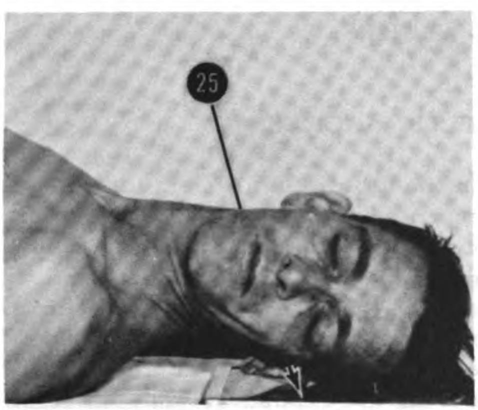
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## THE PETROUS PYRAMIDS

### STENVER'S POSITION (Posterior-anterior Oblique)

Use an 8 x 10 cassette placed lengthwise, or crosswise if two views are placed on the same film. Some clinics will require that both sides be taken for comparison. The patient is placed in the prone position. The head is rotated so the forehead, nose and cheek rest on the film or table. The median plane of the head is at an angle of 45 degrees to the table or film. The chin is pulled to the chest to place the orbitomeatal line in line with the crosswise plane of the film. The affected side is placed nearest the film. The film is centered to a point one inch anterior to the EAM. The central ray is perpendicular to the film. It enters the EOP and comes out through the petrous pyramids. The patient suspends breathing during the exposure. The ID is burned in if a cone is used and placed on the side if no cone is used. Measure through the central ray. The central ray is angled in some clinics. It can be 10, 12, or 15 degrees toward the head.

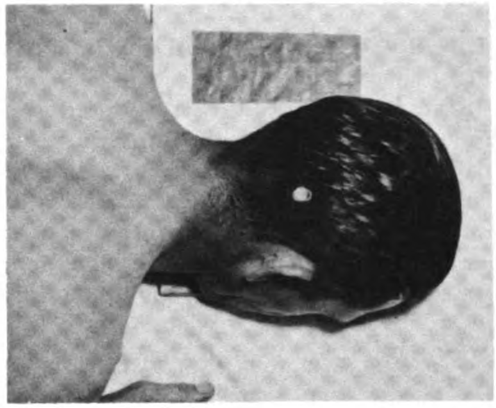
### MAYER'S POSITION OF THE PETROUS PYRAMIDS

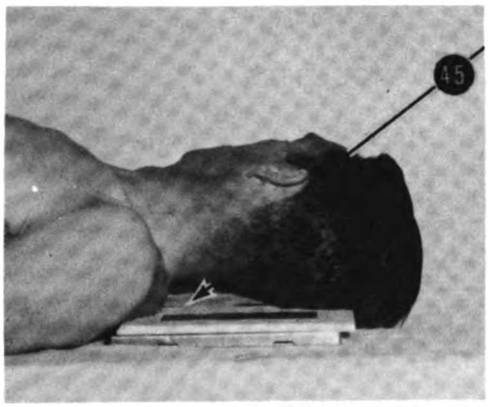
Use an 8 x 10 cassette placed lengthwise. The patient is in a supine position. The head is rotated so the median plane is at an angle of 45 degrees to the film. Tape the ear forward. Pull the chin down to the chest so the orbitomeatal line is on the same plane as the crosswise plane of the film. The central ray is angled 45 degrees toward the feet. It enters the top side of the head and comes out at the EAM next to the film. The film is centered to the EAM nearest the film. The petrous pyramid nearest the film is the one that will be demonstrated. There will be a great deal of distortion in this view so study your radiographs to be sure which structures will be seen on your film. (Both sides are usually taken for comparison).

## THE ZYGOMATIC ARCHES

### MENTOFRONTAL POSITION OF THE ZYGOMATIC ARCHES

Use an 8 x 10 cassette placed crosswise on the table. The patient is in the supine position. The median plane of the head is perpendicular to the table. The chin is extended slightly back so the plane of the face is angled. The film is placed at the top of the head and held in position by placing sandbags behind it. The head can be placed on a sandbag to raise it so the zygomatic arches are centered on the film. The central ray is directed at right angles to the orbitomeatal line. It will enter the head on the median line midway between the angles of the mandible and the mandibular symphysis. The patient suspends breathing during the exposure. The ID is placed on the side. Measure through the central ray.

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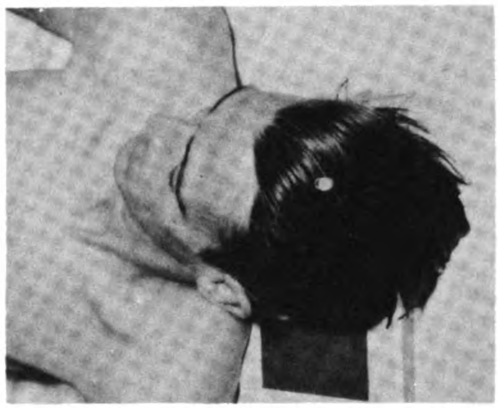
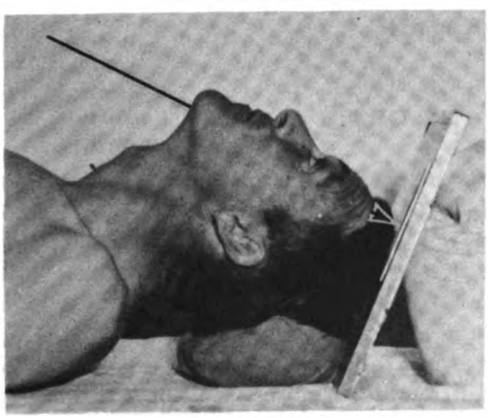
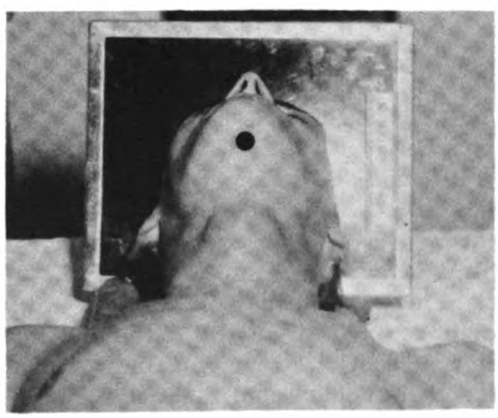






### ANTERIOR-POSTERIOR OBLIQUE VIEW OF THE ZYGOMATIC ARCHES

Use a 10 x 12 cassette placed lengthwise. The patient is in a supine position on the table. The median plane of the head is perpendicular to the table. The chin is pulled down on the chest until the orbitomeatal line is vertical to the film. The central ray is directed at an angle of 30 degrees toward the feet. It enters the glabella and comes out at the angles of the mandible. Center your film to coincide with the central ray. Have the patient suspend breathing during the exposure. Place your ID on the side near the top edge. Measure your central ray.

## THE STYLOID PROCESS

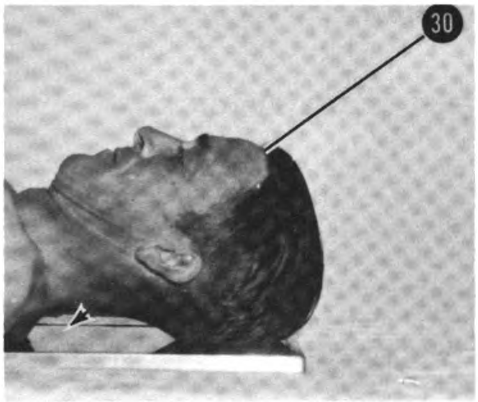
### ANTERIOR-POSTERIOR VIEW OF THE STYLOID PROCESSES

Use an 8 x 10 cassette placed lengthwise. Place the patient in the supine position. Place the film in an angleboard or build the film up with sandbags so it is at an angle of 15 degrees from the table. Center the EAM to the center of the film. Extend the chin until a line from the acanthion to the EAM is perpendicular to the film. The central ray is directed perpendicular to the EAM. Have the patient open his mouth as wide as possible to remove the mandible from the styloid processes. Have patient suspend breathing during the exposure. Burn your ID in at the top if a cone is used or place on side if not. Measure your central ray.

## THE OPTIC FORAMEN

### OBLIQUE POSTERIOR-ANTERIOR VIEW OF THE OPTIC FORAMEN

Use an 8 x 10 cassette lengthwise. Place the patient in the prone position. The median plane of the head is rotated to an angle of 45 degrees to the film. The orbit is centered to the center of the film. The central ray is directed perpendicular to the film. It will enter the back of the head at the level of the orbit and come out the orbit. The patient suspends his breathing during the exposure. The ID is burned in if a cone is used or on the side if not. The angulation of the central ray will depend on the type of skull that you find. The average or mesocephalic head will use 45 degrees, the brachycephalic about 53 degrees and the dochliocephalic about 33 degrees.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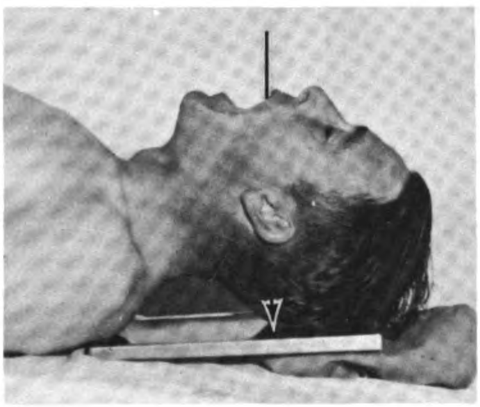
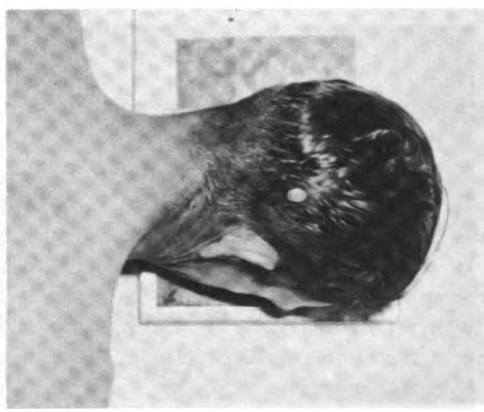




## THE SELLA TURCICA

### OBLIQUE POSTERIOR-ANTERIOR VIEW OF THE SELLA TURCICA

Use an 8 x 10 cassette placed lengthwise. The patient assumes the routine PA position for the skull. The orbitomeatal line is perpendicular to the film. The central ray is directed at an angle of 25 degrees toward the head. It enters the back of the neck and base of the head and comes out two inches above the nasion. The film is centered to coincide with the central ray. The patient suspends breathing during the exposure. The ID is burned in at the top if a cone is used and on the side if not. Measure the central ray.

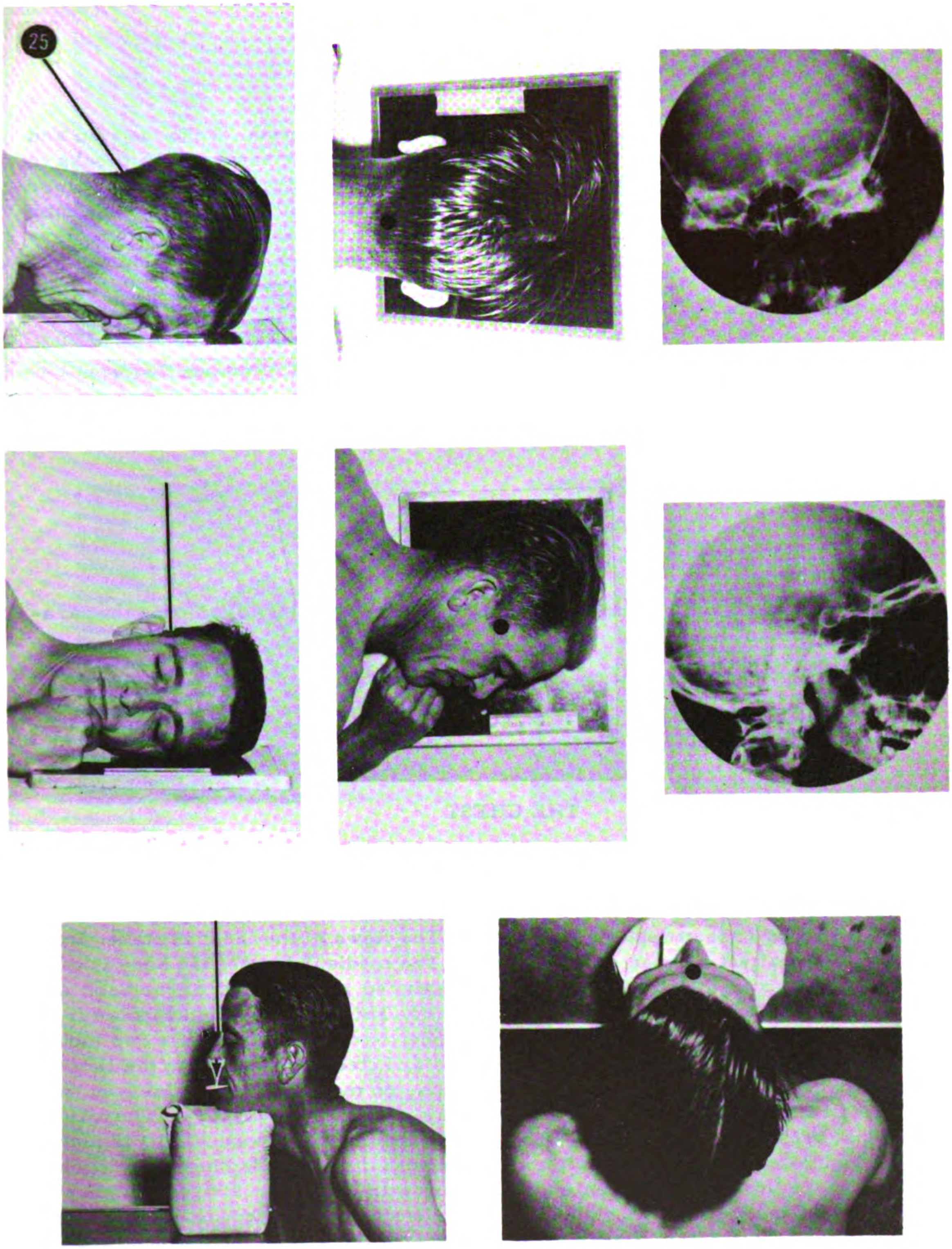
### LATERAL VIEW OF THE SELLA TURCICA

Use an 8 x 10 cassette placed lengthwise. The lateral view of the sella turcica is obtained from a lateral view or position of the skull. A cone is used directly over the entering point of the central ray.

## THE NOSE

### SUPERIOR-INFERIOR VIEW OF THE NOSE

Use an occlusal film. The patient is seated erect. The film is placed in the patient's mouth with enough left out to get all the nose on it. The median plane of the head is perpendicular to the film. The chin is extended and supported by sandbags or other supporting material so it doesn't drop or sag. The central ray is directed perpendicular to the film. It will pass just in front of the glabella and nasion. ID on tape placed in most convenient place. Patient suspends respiration during exposure. Measure through central ray.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## LATERAL VIEW OF THE NOSE

Use an occlusal film. Place the head in the lateral position. Take the film and place it so that it is under the side of the nose. You can use sandbags or blocks to help support it or have the patient hold it with a fist. Be sure that you have it as close to the internal canthus as possible, but don't cause the patient discomfort by forcing a sharp edge into position. Direct the central ray perpendicular to the film. It enters the lateral surface of the nose in the center. Patient suspends breathing during exposure. ID in most convenient place. Measure through central ray. (Usually both sides are taken in a lateral view).

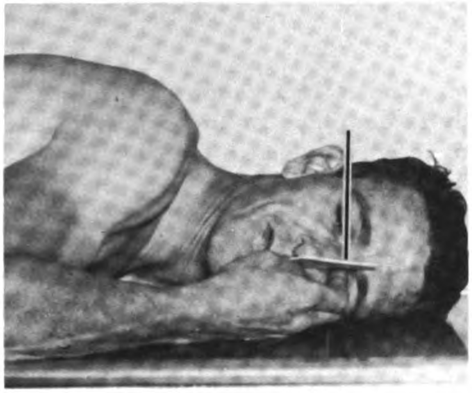
# THE FACIAL BONES

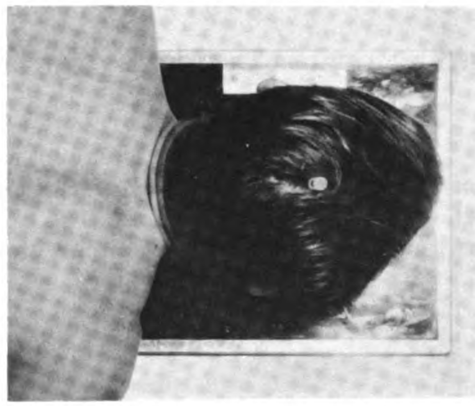
The facial bones can be demonstrated by using the Water's position for the paranasal sinuses without the cone.

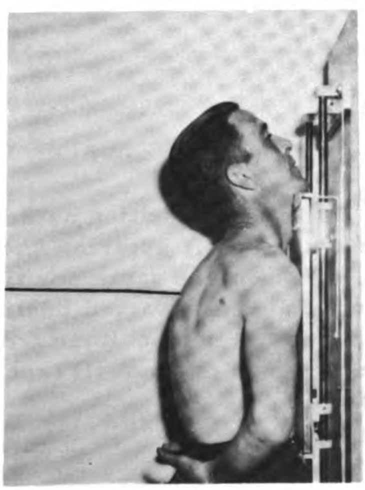
# THE CHEST

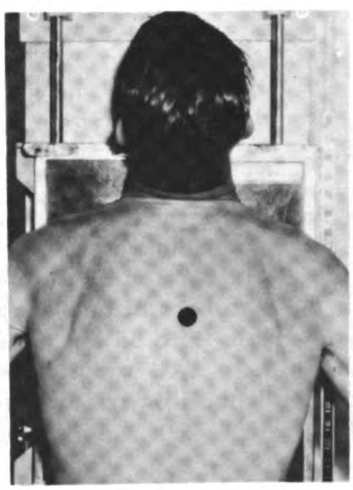
## POSTERIOR-ANTERIOR VIEW OF THE CHEST

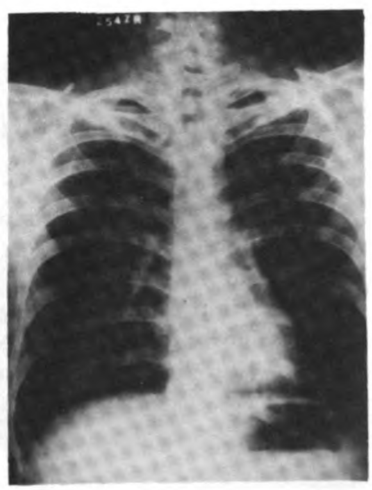
Use a 14 x 17 cassette placed lengthwise. The views of the chest are taken from 72 inches. The patient is in an erect position. The median plane of the body is centered to the center of the film. The hands are placed at the small of the back and then the shoulders and elbows are rolled forward. This removes the scapulas from the lung fields. The film is positioned so the upper border of the film is two inches above the top of the shoulder. The central ray is directed horizontally to the level of the sixth thoracic vertebra. It is at the nipple line on males. On females you will use the fold of the axilla to locate the level of the sixth thoracic vertebra. The patient suspends his breathing after FULL INHALATION during the exposure. ID is placed above the right shoulder. The part is measured with the patient's chest in full inhalation. Measure through the central ray. (Women with large breasts sometimes will be required to place them to the side so that the density of the chest is evened. Generally the lower lung fields will be of less density than the upper fields because of the female breasts.)











LATERAL VIEW OF THE CHEST

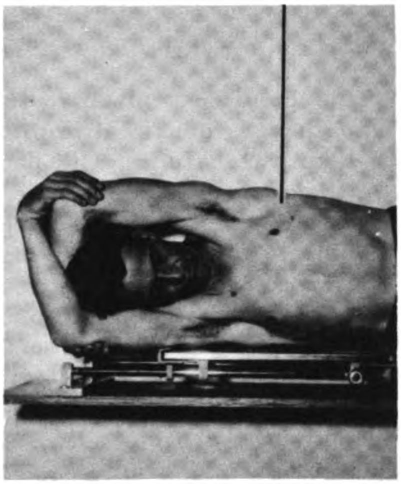
Use a 14 x 17 cassette placed lengthwise. The patient assumes the lateral erect position. The mid-axillary plane of the body is centered to the center of the film. The arms are folded over the head. The film is positioned so the upper edge is two inches above the shoulder in the normal position. The central ray is directed to the mid-axillary plane at the level of the sixth thoracic vertebra. The patient suspends his breathing AFTER FULL INHALATION during the exposure. The ID is placed on the top anterior side of the film. Measure through the central ray and during full inhalation.

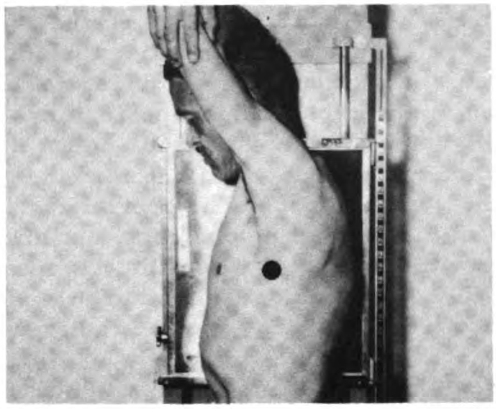
RIGHT ANTERIOR OBLIQUE VIEW OF THE CHEST

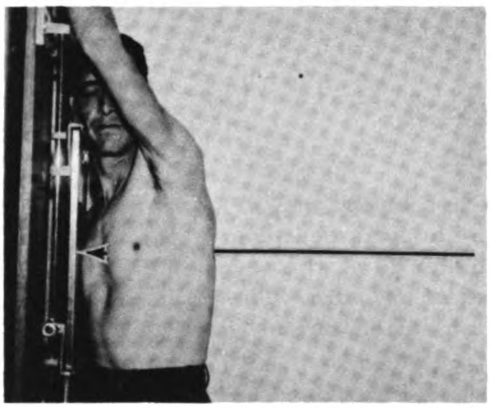
Use a 14 x 17 cassette placed lengthwise. Use the same basic procedures as described in the PA position of the chest, but rotate the body so the right anterior chest wall is against the film. The body is rotated 45 degrees. The arm toward the tube is over the head and the other placed alongside the body.

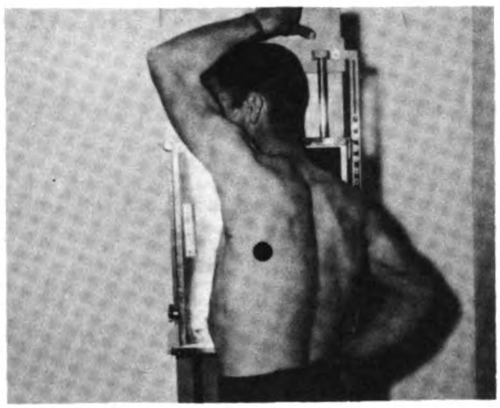
LEFT ANTERIOR OBLIQUE VIEW OF THE CHEST

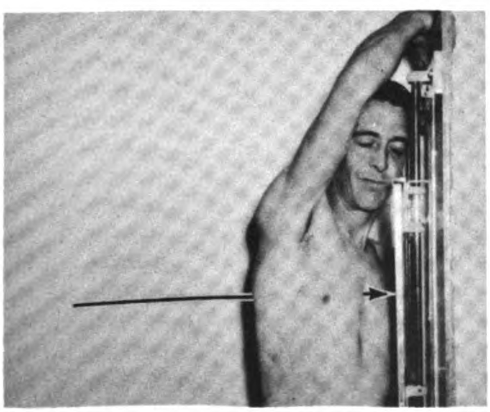
Use a 14 x 17 cassette placed lengthwise. Use the same basic position as described in the PA position of the chest, but rotate the body so the left anterior chest wall is against the film. The body is rotated 55 degrees. Arms in the same position as the right anterior oblique. (The amount of body rotation required is varied in clinics. The right anterior oblique from 45 to 55 degrees, the left anterior oblique from 55 to 70 degrees. Remember to use RAO or LAO side markers on your ID tapes. There is a great deal of confusion when this is forgotten).











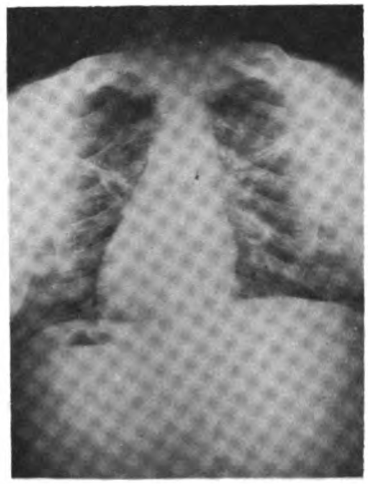
## LORDOTIC VIEW OF THE CHEST

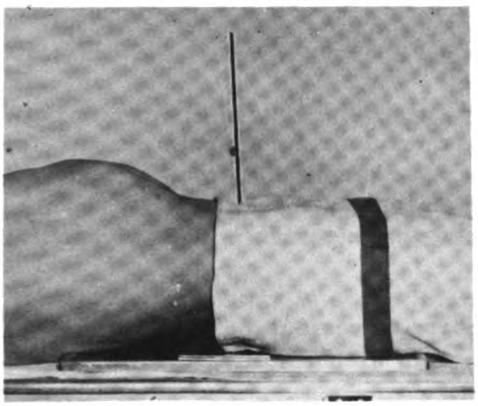
Use a 14 x 17 cassette placed lengthwise. This position is used to show the apices of the lungs. Remember that this area of the chest is denser than the others and correct technique is required to demonstrate them adequately. The patient is placed in an erect anterior-posterior position before the cassette holder. The patient is instructed to place his hands on his hips and keeping his shoulders and back of his neck against the film, walking forward as far as possible. This will lower his chest to a horizontal plane. The central ray is directed horizontally. It will enter at the level of the nipple line and come out through the top of the apices. The exposure is made with the patient's breathing suspended after FULL INHALATION. The ID goes over the right shoulder. Measure through the central ray. (This is a difficult position for weak patients so speed is essential).

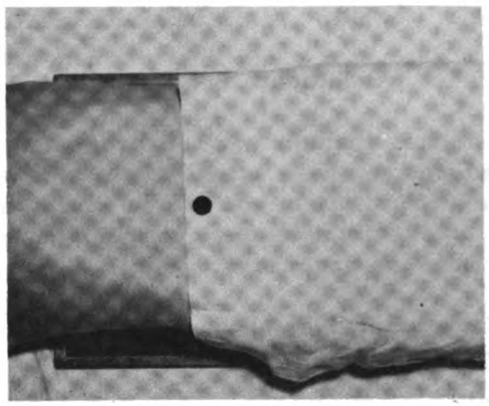
# THE ABDOMEN (KVB)

## ANTERIOR-POSTERIOR VIEW OF THE ABDOMEN

Use a 14 x 17 cassette placed lengthwise in a bucky tray. The patient is placed in the supine position. The median plane of the body is centered to the center of the table. The film is positioned so the lower border is at the level of the symphysis pubis. The central ray is directed to the center of the film. The ID is placed on one side. The patient suspends breathing after inhalation during exposure. Measure through the central ray.







## WORK PROBLEMS

1. Keep a log book during your OJT training of the various number of parts you have taken, what positions you have used, and remarks as to what was inaccurate and needed correction.

For example:

| Date | Part | Positions Used | Correction |
|---|---|---|---|
| 2/7/57 | Hand | PA and Obl. | Film #A-2476<br>Obl. not sufficient |

Week ending 3 October 57 to 7 October 57

Hand .................... 10

Chest .................. 37

Ankle ................... 3

Abdomen ................ 2

In this manner you can present to your supervisor a concrete example of the procedures you have actually been able to do. Also the number of each type will indicate how proficient you can be expected to be on that examination. If you only perform an examination once you will not have had the experience to apply variations when they are necessary.

2. Have supervisor show you some films of parts in various positions and see how well you can identify them.

## QUESTIONS

1. Explain the tube-part-film principle.

2. Explain why the central ray is the ray used for centering.

3. Name five articles used to help immobilize your positions.

4. Name four things that could cause motion.

5. Why is the injured side always placed next to the film?

6. Why should you drape a patient?

7. What determines whether a part is placed on a film crosswise or lengthwise?

8. Why is centering of the part to the film necessary?

9. What is meant by "leading off"?

10. Explain what view, projection and position mean to an X-ray technician.

11. What are the four basic positions used in examinations of the body?

12. Why should you take two views at right angles to each other whenever possible?

13. Explain why angulation of the tube is sometimes necessary.

14. Explain why the body is sometimes rotated.

15. Why is film identification so important?

16. What does oblique anterior-posterior mean?

17. What would the term fronto-occipital mean?

18. What does the name Stenver's call to your mind?

19. What are the basic body positions?

20. Explain or demonstrate what is meant by: supination, pronation, adduction, abduction, flexion, extension, inversion and eversion.

21. Name some body landmarks you can see.

22. Name some body landmarks you can feel.

23. Name some body landmarks you can find by relating them to one or more other structures.

24. Where does the stomach of a hypersthenic type person lay? What type of lung fields would you find in a hyposthenic person?

25. What is a routine position?

26. How do you determine what size and how many films you will need for an examination?

27. What is meant by "measure through the central ray"?

28. Name the positions that you would use to demonstrate the following structures.

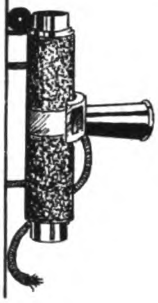
a. Hand
b. Navicular
c. Radial styloid process
d. Olecranon process
e. Glenoid fossa
f. Acromioclavicular articulation
g. Foot
h. Lateral malleolus
i. Tibial tuberosity
j. Intercondyloid fossa
k. Lower two-thirds of the femur
l. Neck of the femur
m. Obturator foramen
n. Symphysis pubis
o. Sacral foramen
p. Lumbrosacral joint
q. Sacro-iliac joint
r. Third lumbar vertebra
s. Sixth thoracic vertebra
t. Fourth cervical vertebra
u. Intervertebral foramina
v. Body of the sternum
w. Seventh rib
x. Eleventh rib
y. Frontal bone
z. Occipital bone
aa. Sphenoid sinus

29. Name the positions that you would use to demonstrate the following structures.

a. Petrous pyramids
b. Zygomatic arches
c. Temporomandicular articulations
d. Styloid processes of the temporal bone
e. Mastoids
f. Nasal bones
g. Vomer bone
h. Mandible
i. Sella turcica
j. Optic foramen
k. Heart
l. Lung

30. Select the structures below that require tube angulation.

a. Elbow
b. Leg
c. Foot
d. Wrist
e. Hip
f. Pelvis
g. Sacro-iliac joint
h. Frontal bone
i. Maxillary sinuses
j. Cervical spine
k. Humerus
l. Clavicle
m. Scapula
n. Knee



# CHAPTER 7

## NURSING PROCEDURES

What does an X-ray technician have to know about nursing? And just what is nursing?

Nursing is the CARE given to sick and injured people. The purpose of nursing is to maintain, promote and restore the patient to health. Nursing is protecting the patient from contracting a new infection, reinfection or a new condition. Nursing is assisting in the cure of a patient's disease or condition.

The X-ray technician is responsible for the nursing care of the patient when he is in contact with the patient. He helps, as do all the doctors, nurses, and medical specialists, in maintaining, promoting and restoring the patient to health.

Now, how does he do all of this? He learns how to talk to sick and injured patients of all ages, races and creeds so they will know he is friendly, sympathetic, assuring, EFFICIENT, calm, self-controlled, soft-spoken and INTERESTED ALWAYS. He knows sterile and aseptic technique, how to handle, move or lift a patient without adding injury, and becomes familiar with injection methods and isolation techniques. He assists in the cure of patients by performing all authorized and necessary examinations requested by the doctor. To do this he must know how to prepare the patient, what equipment is to be used and what his specific duties are.

### THE CLINIC ENVIRONMENT

Although the X-ray clinic is not a hospital ward it is an integral part of the hospital as a whole. It should be cheerful and pleasant.

#### THE X-RAY TECHNICIAN

It should go without saying that an X-ray technician should be clean. A patient's concept of a hospital is a place of meticulous cleanliness. He thinks of it as white

and germless. An X-ray technician who is not an example of this cleanliness will provide the patient with a shadow of doubt as to the type of care he is going to receive.

Personal hygiene is not difficult once you establish the habit. In the clinic you should have some means of keeping your hands washed. Your clothing should be protected from solutions as much as possible. Many hospital uniforms or "whites" are stained with various materials and unless they are seen to be clean should never be worn. Hospital whites that are torn should not be worn. Just remember that it is YOU who will be wearing them and it is up to YOU to present the best appearance possible. If you receive clothes which are torn, it is up to you to see that they are mended or exchanged. Not only have you personal pride, but you have a hospital responsibility. YOU WILL NEVER HAVE AN EXCUSE FOR APPEARING SLOPPY BEFORE YOUR PATIENTS. When others do not set the example it does not relieve you of the responsibility. Always keep spare clothing close at hand.

## THE CLINIC

An X-ray clinic will reflect the type of technicians in it. One of the most arduous tasks asked of an airman is to "clean" something. Somewhere in the make-up of man there is an aversion to mops and water. It is a natural feeling of the adolescent boy to wonder at the necessity of cleanliness. You are no longer a boy and you no longer have to wonder about the necessity of cleanliness. You may still possess the aversion to the mop, but in a hospital you do not HESITATE to use the mop. You keep things neat and orderly at all times.

Many technicians fail to properly clean their cassettes. The bakelite front of a cassette will show fingerprints, skin oil and other matter. To a patient these marks are displeasing. The cassette should be cleaned prior to each procedure or covered with a towel or napkin when the patient is to come in contact with it. This is absolutely necessary when contamination may have occurred. Cardboard holders that have been spattered with blood or body fluids should be covered with a napkin or destroyed. No one would care to place a part of his body on a dirty piece of equipment. You must think as your patient would think about such practices. The bakelite surface of your table is to be considered in the same light. Keep the surface clean by wiping it with a damp cloth and then with an alcohol sponge. Although this may take a second or two, you will never be so busy that you JUST CANNOT do it. You are there to protect yourself and the patients from infection, reinfection, or a "plain revoltin' development".

By having a place for everything and keeping everything in its place, you will not have a great deal to take care of when you end the day. Equipment will not be strung all over when you need it. Clean your equipment after each use and you will be ready to use it for the next patient.

## ETHICS IN EXAMINING FEMALE PATIENTS

At no time will a technician perform examinations on female patients unless there is a female technician, friend or nurse present in the room, unless otherwise directed by the doctor. Unnecessary exposure of the female body is to be avoided at all times. When there is a female technician in the clinic, she will take care of all female patients.

# HANDLING AND MOVING SICK AND INJURED PATIENTS

In the X-ray clinic you will be required to do a great deal of moving and handling of your patient. It is the poor X-ray technician who knocks, pushes and pulls without purpose. Not only is it hazardous to the patient's physical and mental welfare, but the technician is generally quite fatigued after a 100-patient day. The technician who knows how to lift and move a patient saves both his own strength and that of the patient. He also will lessen the chance of adding further injury to the patient.

You will use these lifting and moving techniques a great deal in positioning your patient in the clinic as well as when doing bedside examinations.

Your patients will come to you in wheel chairs, stretchers and cumbersome casts. You will be required to move patients up and down your radiographic table and from side to side on it. You will have to place patients in sitting positions in their beds or roll them up to place a film beneath them. You will have to take patients from stretchers and place them on your table. Removing and replacing patients into wheel chairs is a frequent task. All of these things, plus changing your patient's positions from AP to PA or lateral, will call for knowledge of lifting and moving.

## PRINCIPLES OF MOVING OR LIFTING

- Place your body in the correct position before moving or lifting.
- Place your feet far enough apart to maintain proper balance and provide a basis of support.
- Hold the patient or part as close to your body as possible to eliminate all unnecessary strain by centralizing total weight within your grasp.
- Stoop to working level and keep the back straight.
- Slide, rather than lift, whenever possible.
- When a patient is too heavy for you to move alone, get help.
- When two or more persons are moving or lifting, give a signal and move or lift in unison.

## TECHNIQUES OF MOVING OR LIFTING

- Preparation of the patient: When you are going to move or lift a patient, tell him exactly what you are going to do and how he can help you. Have any equipment that you need in place. If it is a stretcher, surgical cart, or a wheelchair, make sure someone holds it steady, both when you place the patient on and when you take him off. If the patient is draped, arrange the draping so the patient remains covered during the transfer.
- Correct position for moving: Face the direction in which you are going to move the patient. Place one foot well forward of the other. Stoop to

working level by flexing the knees, but keep the back straight. Put your arms under the patient and hold your elbows close to your body. Move or lift the patient by shifting your own weight from one foot to the other.

- To move the patient toward you: With the patient resting on your arms, slide your arms on the bed or table and shift your weight from your front foot to your rear foot.

- To move the patient away from you: With the patient resting on your arms, slide your arms on the bed or table and shift your weight from the rear foot to the front foot.

- To lift the patient up: Flex your knees and place your arms under the patient. Keep your elbows close to your body and straighten your knees so that there is equal weight on both feet.

- To let a patient down: Keep your elbows close to your body and flex your knees. Equal weight should be on both feet.

- Moving patient up or down table: A sheet should be placed on the table before the patient is removed from a cart or chair. With a sheet you can slide the patient up or down or to either side of the table. Trying to slide moist skin over a radiographic table isn't a good procedure. Stand in the correct position on the side or end that you want the patient moved. Grasp the sheet close to the body and shift your weight from your front foot to the rear foot. This method will allow you to make fine adjustments to your position without strain or over-exertion on the part of the patient.

- Helping the patient to sit up: Stand in the proper position on the side of the bed or table. Put your near arm under the patient's near shoulder. Have the patient do the same thing to you. Place your other arm behind the patient's head and shoulders. Raise the patient by shifting weight from front to rear foot.

- Turning a patient on side: Place your patient's knees in a flexed position. Put your hands on the patient's far shoulder and hip and roll him toward you gently by shifting weight from your front foot to the rear foot. If he is on a sheet in the radiographic room, you can then pull him to the center of the table with the sheet in the manner previously described.

- Turning patient from his back to his stomach on the table: In some examinations you will have to take one film in an AP and another in a PA. You will also need to remember that you will generally be using the center line on the table. Take the sheet as explained previously and draw the patient to one side of the table. Then move him into the lateral position as described. Extend his legs out. Place his upper arm across the front of his body to his shoulder so that you can reach his hand from behind. Gently pull this hand and arm toward you while keeping your other arm under the chest area. Shift your weight from the front foot to the rear foot. Two persons are sometimes necessary to turn a patient from his back to his stomach.

- Helping patient to sit on side of table or bed: Turn the patient on his side

as described. Put one arm under the shoulder and the other behind his knees with your hand under the lower thigh. Have the patient put his hands around your neck and on your shoulder. Slowly straighten your knees by shifting your weight from the front foot to the rear foot and bring the patient into a sitting position. Let him place both hands on your shoulders until he gets accustomed to the position.

- Placing a patient into a wheelchair from the table or bed: Bring the patient into a sitting position as described. Place the chair parallel to the bed or table and be sure it is steady. Dress the patient in his coat or robe and his slippers. Have the patient place his hands on your shoulders. Put your hands on the patient's sides between the axilla and the hip. Hold onto the patient and let him slide off the bed and stand on the floor. Pivot with the patient and lower him into the chair by flexing your knees and shifting your weight from the front to the rear foot. The same procedure is done when you remove him from the chair to put him on the table.

- Moving a patient from a stretcher to a table: Place the cart at right angles to the table if possible. Three men are necessary for a helpless patient. They all form on one side of the cart in the proper position with their knees flexed. One man places his arm under the patient's shoulders, supporting the head in the crook of his elbow. The other arm is placed under the patient's back. The second man places his arms under the patient's back and thighs. The third man places his arms under the patient's thighs and calves. At a signal they slide the patient to the side of the bed. Adjusting their position again they lift the patient together by straightening out their knees. They turn and place the patient onto the table. The same technique is used to remove the patient from the table. When a radiographic room is too small to bring the cart into the room or allow it to be placed at right angles to the table, the most feasible modification must be made.

- How to move an injured arm or leg: Put both hands under the joints above and below the injury. Raise it slowly and gently. A pillow should be used to support the arm or leg. It should be large enough to support the whole limb. Place the hand or toes slightly higher than the rest of the extremity.

## BEDSORES

Patients who are prone to develop bedsores are those who have had a prolonged illness. Bedsores are caused by poor circulation due to pressure. The areas that become involved are elbow, occiput, upper vertebral border of scapula, lumbar spinous processes, anterior and posterior superior iliac spines, greater trochanters, ischial tuberosity, sacrum and heels. Bedsores are also common to patients who are paralyzed, have been unconscious for a length of time, are cardiac cases, or have been in casts, splints, or in traction.

Gentle movement is necessary with these patients. Care is necessary when you move them by placing your arms away from these areas.

# INJECTION METHODS

In X-ray you should know how to prepare and perform injections. Although you will not be in the "shot line" it is important that you know the correct methods of using certain drugs, syringes and needles. In some clinics you will be expected to prepare your own injection trays, sterilize your equipment, and prepare your patient to receive injections.

Most of the injections that are done in X-ray are those used to introduce various types of contrast media into the system. You will learn more about contrast media in a later chapter.

## METHODS OF INJECTION

There are five means of injecting substances into the body. These methods are selected with definite purposes.

INTRADERMAL. This term means injection into the skin. The injection is made in the superficial layers of the skin. In X-ray this method is used to test for allergic reaction to various contrast media.

SUBCUTANEOUS. The term subcutaneous means injection under the skin. This method is used to administer immunizations, sedatives, or, as in X-ray, drugs that will counter reactions to contrast media.

INTRAMUSCULAR. This term applies to injection into the muscle. This type of injection is not used much in the X-ray clinic. It is primarily used for drugs not suitable for intravenous injection.

INTRAVENOUS. This is an injection into the vein. This type of injection is used extensively in the X-ray clinic. However, a technician DOES NOT give these injections. This is a doctor's responsibility. There may be an emergency situation where you will give an intravenous injection, but it will be an extreme emergency.

INTRASPINAL. This is an injection into the spinal canal. In X-ray this method is used to introduce contrast media into the spinal space. As a technician you will NEVER attempt to perform an intraspinal injection.

## SYRINGES AND NEEDLES

TYPES OF SYRINGES. Syringes are instruments used to hold the material to be injected. They are composed of a barrel and a plunger. Syringes must always be sterile. A syringe should be large enough to hold the required amount of media. Syringes are always handled with aseptic technique.

- Tuberculin syringe: 1 cc in capacity - scaled in 1/10 of a cc. It is used for very small dosages when fractions of a cc or a small number of minims (a drop or one sixtieth of a fluidram) are required.

- 2 cc syringe: 2 cc capacity - scaled in minims and 1/2 cc. Used for in-

jections of 2 cc or less.

- 10 cc syringe: 10 cc capacity - scaled in 2/10 cc. Used for injections of 5 to 10 cc.

- 20 cc syringe: 20 cc capacity - scaled in cc. Used for injections of 10 to 20 cc.

- 30 cc syringe: 30 cc capacity - scaled in cc. Used for injections of 20 to 30 cc.

- 50 cc. syringe: 50 cc capacity - scaled in cc. Used for injections of 20 to 50 cc.

- Luer Lock Syringe: A syringe that has a lock built in to hold the needle. It can be of the various sizes mentioned.

Syringes are identified by a number imprinted both on the barrel and on the plunger. This helps you to find the right plunger and barrel for each syringe when they are separated.

TYPES OF NEEDLES. Needles are measured by their gauge. This gauge is the diameter of the opening in the needle. The smaller the gauge number the larger the opening and length of the needle.

Intradermal needle: 25 gauge x 1/2 inch in length.

Subcutaneous needle: 23 gauge x 3/4 inch in length.

Intramuscular needle: Deltoid - 23 gauge x 3/4 inch in length.

Gluteal - 21 gauge x 1-1/4 inch in length.

Intravenous needle: 21 gauge x 1 inch.

19 gauge x 2 inches.

Intraspinal needle: Lumbar puncture needle - 7 inches in length.

CARE OF SYRINGES AND NEEDLES. All syringes and needles must be sterile before they are used. You will use a syringe and needle for one injection only. After each injection the syringe and needle will be rinsed with water and resterilized.

Generally, you will rinse the syringes and take them to central supply where they will be properly sterilized in an autoclave. If you are in a facility that has a central supply you will know that it is the center for preparation of the various tray set-ups required in the hospital. An autoclave is a device which sterilizes equipment with steam under pressure. It is the recommended type for sterilization.

If you do not have a central supply and are required to sterilize your own equipment, boil the syringes and needles for AT LEAST twenty minutes in your individual sterilizer. Be careful that you do not forget to put distilled water in your sterilizer, or let your water boil away. If the water boils away, the sterilizer may be ruined.

Check needles for barbs by drawing needle across your finger or gauze strip. If it snags, there is a hook. You should obtain an emery stone to use in filing down such hooks.

## PREPARATIONS FOR INJECTIONS

A basic injection tray is usually set up in a clinic. It will have a sterile jar of 2 x 2 or 4 x 4 alcohol-soaked gauze pads or cotton, a container for 70 per cent alcohol, forceps, Petri dish of various size sterile needles, container for sterile syringes of various sizes, and the bottle or ampule of material you are going to inject.

### PRECAUTIONS

1. Always use sterile techniques in the preparation and administration of injections.
2. If syringes have been in alcohol, rinse with sterile water.
3. Match numbers of syringe barrel and plunger.
4. Test needle for hooks or barbs on alcohol cotton or gauze.
5. Be sure to use a separate syringe for each injection.

### PREPARATION OF SYRINGE AND NEEDLE

1. Using the forceps that are kept in the container of alcohol, remove syringe barrel from container or pack.
2. With the forceps pick up plunger with the same number as barrel and, while holding barrel with thumb and index finger on the outside, insert it into the barrel.
3. With the forceps, pick up the size needle that you are going to use and attach it to the syringe.
4. Tighten the needle but do not touch the needle itself.

### PREPARATION OF INJECTION FROM A BOTTLE

1. Use forceps and remove alcohol pad from container.
2. Swab the rubber stopper on the bottle with the alcohol sponge.
3. Assemble your syringe and needle as above.
4. Draw back the plunger of your syringe to the amount of solution you want to put into the syringe.
5. Insert the needle into the rubber stopper of the bottle and push in the plunger. This is necessary to prevent a vacuum that would make it difficult to get your solution out of the bottle.

6. Invert the bottle and pull back on the plunger until you have the desired amount of solution in your syringe. Keep the syringe at eye level to be certain that you have the correct amount.

7. Withdraw the needle and cover it with another alcohol sponge.

PREPARATION OF INJECTION FROM AN AMPULE

1. Wipe the file that comes with the ampule with an alcohol sponge.

2. Wipe the neck of the ampule.

3. File the neck, then take an alcohol sponge and place over top. Break the neck at the file marks.

4. Assemble syringe and needle as previously described.

5. Tip the ampule to an angle of 45 degrees.

6. Insert the needle in the ampule and withdraw desired amount of solution.

7. Cover the needle with an alcohol sponge after it is withdrawn from the ampule.

INTRADERMAL INJECTIONS

1. Explain to the patient what you are going to do.

2. Swab site of injection with alcohol sponge.

3. Hold syringe upright and expel all air bubbles.

4. Insert needle at an angle of 15 degrees, just under the skin, so that a raised area is seen.

5. Inject the prescribed amount.

6. Cover the needle with an alcohol sponge and withdraw the needle. Have patient hold sponge over site until bleeding stops.

SUBCUTANEOUS INJECTIONS

1. Explain to the patient what you are going to do.

2. Swab site of injection with an alcohol sponge.

3. Hold syringe upright and expel air bubbles.

4. Make a firm cushion of flesh at the injection site.

5. Insert needle quickly at an angle of 45 degrees.

6. Draw back plunger if no resistance is felt and check for blood in the

syringe. If you see no blood inject the solution slowly.

7. Place an alcohol sponge over the needle and withdraw needle quickly.

8. Massage site of injection with alcohol sponge for a moment.

INTRAMUSCULAR INJECTIONS

1. Explain the procedure to the patient.

2. Swab site of injection with alcohol sponge.

3. Hold syringe upright and expel the air bubbles.

4. Make a firm cushion of flesh at the injection site.

5. Insert the needle at an angle of 90 degrees.

6. Draw back on the plunger to check for blood. If there is no blood, slowly inject the solution.

7. Place an alcohol sponge over the needle and withdraw the needle quickly.

8. Massage the site of the injection for a minute with an alcohol sponge.

9. The site of injection is in the deltoid muscle or the upper right outer quadrant of the buttocks.

INTRAVENOUS INJECTIONS

1. Prepare solution as prescribed by doctor or manufacturer.

2. Assemble the syringe and 19 gauge needle.

3. Withdraw solutions from bottle or ampule as shown before.

4. Take a tourniquet (usually a piece of rubber tubing) and the filled syringe to the patient.

5. Select the injection site and place tourniquet under arm above the site of the injection. The usual site is the veins on the anterior surface of the elbow.

6. Tighten the tourniquet.

7. THE DOCTOR WILL INSERT NEEDLE.

8. When you see blood in the syringe, remove the tourniquet.

9. THE DOCTOR WILL INJECT THE SOLUTION.

10. Place alcohol sponge over needle and doctor will withdraw the needle.

11. Have the patient flex his arm, holding the alcohol sponge over injection site until bleeding has stopped.

12. STRICT ASEPTIC TECHNIQUE IS EMPLOYED IN INTRAVENOUS INJECTIONS.

INTRASPINAL INJECTIONS

1. Explain the procedure to the patient.

2. Assemble and set up equipment.

3. Position patient in proper position: this position is with the patient turned on his side near the edge of the table. The legs are flexed on the abdomen with the head on the chest. Shoulders and hips are in the same vertical plane.

4. The doctor (or with prior instructions, the technician) paints the skin area with skin disinfectant. The doctor anesthetizes the lumbosacral region. He inserts the needle into the spinal canal, measures the pressure with the manometer and collects specimens in the test tubes.

5. The technician watches condition of patient (color, pulse, and respiration).

6. Receive and label the specimens.

7. Caution patients to remain FLAT IN BED FOR TWO HOURS OR MORE AFTER THE EXAMINATION. If they do not remain flat in bed, they may be subject to severe headaches.

## STERILE OR ASEPTIC TECHNIQUE

The following facts are based on the major principle of surgical aseptic technique that all articles coming in direct or indirect contact with a wound MUST be sterile. As an X-ray technician you are bound to follow this principle WITHOUT DIRECT SUPERVISION.

1. An article is either sterile or unsterile. There is no in-between. If any doubt exists, you must consider the article to be unsterile.

2. Sterile articles must be kept covered until ready for use.

3. Only the outside of the wrapper or cover is touched when opening a sterile package or container.

4. A sterile article is handled with a sterile instrument or sterile gloves.

5. Once an article is removed from a sterile container it is not returned to that container.

6. When removing an article from the sterile container, use the forceps provided. Only that part of the container and that part of the forceps which is covered by disinfecting solution is considered sterile. Always hold the tip of the forceps downward. Remove the cover of container. Hold the cover in one hand. Remove the article with the forceps in the other hand. Replace the cover. If you must lay the cover down, turn it upside down on a flat surface.

7. When a container becomes contaminated, dispose of it at once. <u>If you cannot do it immediately, turn the cover to show it is contaminated.</u>

8. Avoid reaching over a sterile field.

9. Edges of sterile towels are considered contaminated after contact with an unsterile surface.

10. Keep instrument handles out of sterile fields.

11. Pour sterile solutions so there is no contact between the bottle and sides of the container.

You must learn these principles and rules. Your patient cannot afford for you not to know them. It will take practice and caution to do these things. You will have to concentrate. Do not allow yourself to be interrupted when you are working within a sterile area. When you see someone violate these rules, tell him that he has contaminated the equipment or field. Tact is necessary with rank, but do not hesitate to tell the person immediately.

## ISOLATION TECHNIQUE

You may be called upon to do an examination in an isolation ward. You should be acquainted with the procedures for entering and leaving such a room. The purpose of an isolation room is to confine the disease to the patient and protect the people working with the patient and other patients. Again, you must follow the rules without direct supervision.

### EQUIPMENT

Take all necessary equipment with you that you will need. You should only have to enter the room once. Drape your machine with a clean sheet provided by the wardman. Your cassette or film should be placed in a clean pillowcase. You should have the wardman or nurse available to help you and to answer any questions you may have on how to maintain the isolation technique. The source of trouble you will find in radiographing in isolation rooms is the decontamination of the cables and wheels of your portable unit. These should be wiped down with a disinfectant before being brought back to the clinic. With the film encased in the pillowcase it should be free from contamination.

## HANDWASHING TECHNIQUE

Wherever possible use a sink with running water. Scrub the hands and forearms with soap and water. Be particularly careful to scrub around the fingers and nails and let the water drain off your finger tips. Dry your hands with paper towels.

Wash your hands before and after you remove a gown. Wash your hands before leaving a ward, going to meals or after each task.

## MASK TECHNIQUE

Masks are washed, rolled and placed in a container and sterilized in an autoclave. When a mask is used once it will be placed in a container for soiled masks. You can wear a mask until it becomes moist, but once it is moist it is contaminated. Do not lay a mask down, but get rid of it immediately.

Before putting on a mask wash your hands. With a pair of sterilized forceps, remove a mask from the container. Open the mask by pulling the strings. Place the mask over the nose and throat and tie it at the back of the head and neck. When you have finished with the mask, wash your hands again. Untie the mask and hold the string ends in your hand. Touching only the strings, drop your mask into a container for soiled masks and wash your hands again.

## GOWN TECHNIQUE

The "discard" gown method is the one generally followed by X-ray technicians. You will use a clean gown each time it is necessary to enter an isolation room. You will also wear gloves when working with patients who have syphilitic rashes, smallpox, or when exposed to dressings of patients who have tetanus or gas gangrene.

When using gloves, wash your hands. The gloves should be sterile. Put on the gloves before entering the room. When you have finished, wash the gloves under running water and dispose of them as directed by the wardman or nurse.

What is the correct way to put on a gown?

- Wash you hands and put on a mask.
- With your palms together, slip your hands inside the gown and remove from the hook.
- Touching only the inside of the gown, work your arms and hands through the sleeves.
- Place the fingers inside the neck and draw the gown into place.
- Tie the gown at the neck in back.
- Grasp the back edges of the gown and bring the center back.
- Lap the edges of the gown together in the back and hold flap in place.

- Grasp the end of the belt and with the free hand bring to the back.
- Bring the other belt end to the back.
- Tie belt in back tightly enough to keep flap in place.
- Shrug your shoulders once or twice to give room.
- Push your sleeves up to convenient working level if you wish.

What is the proper way of taking a gown off?

- Untie the belt and push sleeve two inches above the contaminated level.
- Wash your hands and forearms without touching cuffs of gown.
- Place two fingers under cuff and pull sleeve down over hand without touching outside of gown.
- With hand inside the sleeve, draw the other sleeve down over the other hand.
- Slip out of the gown by working hands up to the shoulder seams of the gown.
- Keeping the hands inside, lift the gown off the shoulders.
- Fold the gown by bringing the palms of the hands together at the shoulder seams of the gown.
- Turn contaminated side in so the inside of the gown is out and place it carefully into the receptacle used for discarded gowns.
- Wash your hands again.

## ENEMAS

Enemas are given in the X-ray clinic. The technician uses the enema technique in the introduction of fluid into the colon to examine it. You should understand the procedure used to give enemas. Because a great deal of the success of an enema requires the cooperation of the patient, it is important that the technician explain very clearly what he is doing and what will happen to the patient during the examination. A frightened or uncooperative patient can produce unpleasant and dire results.

There are two types of enemas which you will probably be required to perform. These are the cleansing enema and the barium enema. The difference is that the cleansing enema will remove all gas and feces that will interfere with the examination, and the barium enema is a retention type enema used to examine the colon.

In most hospitals the patient is given a cleansing enema on the wards or is re-

quired to perform a cleansing enema at home. As part of the preparation for an examination in the X-ray clinic, it is also done two to three hours before the examination.

## EQUIPMENT

All equipment to be used should be prepared and ready for use. You will need the following articles:

- Enema can
- Rubber tube - for a cleansing enema this tube is about 18 inches long. The tube used for an examination is about 6 feet long. A piece of glass tubing is placed in the lower third of the tubing so the flow of the solution can be checked.
- Clamp
- Rectal or Enema Tip — The Air Force uses a disposable plastic tip in many clinics. If this item is not available sterilized enema tips will be used.
- Lubricating Jelly
- Curved Basin
- Rubber Cover Sheet
- Tongue Blade
- Toilet Tissue

## HOW TO PREPARE PATIENT AND EQUIPMENT

The patient is informed of exactly what is going to happen to him. He is placed on his right or left side in the Sim's position. The Sim's position is a position with the patient on his stomach. One leg is flexed so that the anal area is exposed. He is told that his cooperation is necessary if the enema is to be successful. If the patient is tense, his muscles will not be relaxed and he will be subjected to cramps which will make it difficult to get the solution into the colon. He should be instructed to breathe deeply through his mouth to relieve the minor distress he will feel. Usually the patient will feel cramps as the solution enters and fills the colon. He should be assured that when he feels the cramps the injection of the fluid will be stopped until they are passed.

The equipment is prepared by attaching the enema tip to the rubber tubing that leads from the enema can. The enema can is filled with solution and suspended from the enema standard. The solution is allowed to run through the tube and then clamped. Take the tongue blade and place some lubricating jelly on the toilet tissue. With the toilet tissue lubricate the enema tip. Leave the tissue around the tip until you are ready for it.

Place the rubber sheeting under the patient's buttocks. The curved basin is put next to the anus. Open the clamp and allow a small amount of the solution to run into the basin so that all the air is expelled from the tube.

## ADMINISTRATION OF AN ENEMA

When everything is in readiness, the patient is exposed. The upper buttock is raised and the anus located. The enema tip is inserted about 3 to 4 inches into the rectum. Hold the enema tip with the left hand. Whenever possible, allow the patient to insert the enema tip. If a cleansing enema is being given, hold the can about 18 inches above the anus. Allow the solution to flow slowly. When the patient complains of discomfort or cramps pinch the tubing for a few moments. This will allow the muscles to relax. Have the patient breathe deeply. When all the solution is gone or when the patient has taken all he feels he can hold, clamp the tube and remove the enema tip.

If the patient has a relaxed anal sphincter, some device is necessary to enable him to retain the enema. This can be a special retention catheter or a roll of one-inch gauze can be placed over the enema tube before insertion and held against the anus by the patient.

After the enema is given the patient is allowed to expel the enema if it is a cleansing enema. For an examination the patient is examined during the filling process and then allowed to expel the enema. You will learn more about the examination in a later chapter.

One other thing should be kept in mind. The solution should be warm. The temperature should be about $100^{\circ}$ Fahrenheit for a cleansing enema, but only about 85 to $90^{\circ}$ for the examination enema. The temperature for the examination enema will inhibit natural peristaltic action in the colon and will allow the patient to retain the solution for a longer period of time.

## BEHIND AND AHEAD

You are now familiar with methods for moving and lifting patients, the necessary clinical appearance and atmosphere, and sterile technique. You know how to enter an isolation room and prepare and administer an enema. You will find that many related fields will overlap into X-ray and as your experience increases you will understand many of the reasons why it is necessary to you to know something about them. Working in the wards and in the operating rooms will call for constant questioning and learning. The essence of learning is to question everything of which you are unsure or don't know about. A person dealing with the sick and injured must know the answers. When you are in contact with a patient you are not just an X-ray technician, but the whole hospital. If you apply the knowledge that you have learned in this chapter your patient will know that you are giving him the care he deserves, and the best care he can get.

Ahead of you will be a chapter on the procedures used in the darkroom. Up to this point you have been doing things with films. Now you must learn how to process

these films. Darkroom procedures will cover a number of different tasks that are involved in the area of the darkroom. You will learn how to develop films, the steps in processing, how to avoid distracting and misleading artifacts on film, how to load and unload films and hangers, how to clean and test screens and why the darkroom means success or failure in your examination.

## WORK PROBLEMS

1. Go to a ward room with one man and practice moving and lifting as given in the chapter. Also take some time and watch how the sick, very sick and severely injured patients react to moving on the actual ward. Apply the principles of moving and lifting in your own clinic until you can do them with ease. Any motion that you make which is clumsy will indicate that you are not moving with forethought. Train yourself to apply what you know and see how much faster and easier you can perform your examinations and how much more cooperation you receive from your patients.

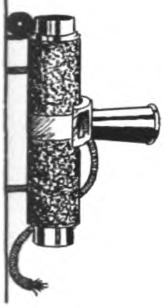
2. Go to the Outpatient Clinic where routine immunizations are given. Watch how each of the various types of injection methods are done. After you have watched, ask one of the technicians to check you out and try a few for yourself. You'll never learn except by doing. Go to the laboratory and watch how the lab technician withdraws blood. Note methods used to penetrate veins. Arrange to see spinal taps, either in your clinic or in the wards.

3. If you do not have an isolation section in your facility, ask your supervisor to set up a mock isolation situation. Practice the isolation technique. If you do have an isolation set-up, go to the ward and follow the wardman through his particular routine. Practice until you can perform without error.

4. Go to central supply and watch how they prepare and sterilize the various packs. Try to help them so you can get the feel of sterile technique. Practice assembling needles and syringes and preparing injections until you have the procedures down complete. Check and recheck yourself for errors.

5. Arrange to see and assist in performing enemas. These are done in the wards, your clinic and sometimes in the Outpatient Clinic. Practice assembling the proper equipment. Take special efforts to watch reactions of patients of various ages, sexes and conditions in regard to enemas. Learn the best techniques for relieving tension and what ethics must be practiced.

6. Check your appearance and when arriving at your clinic spend a few minutes dusting, arranging and wiping down your equipment. Prepare and organize for your day's work. Develop the habit of neatness and orderliness.



# CHAPTER 8

# DARKROOM TECHNIQUES

You are now ready to learn about darkroom techniques. Most apprentices learn these procedures in their first days in the clinic. There are many darkroom procedures to be learned. Many technicians look on the tasks as minor in importance, but this is not so. A good X-ray clinic will have a good darkroom. A good darkroom is created by technicians who know that the darkroom is the key room in the clinic. Good radiographic technique, accurate positioning and careful handling of your patient can be easily voided by poor darkroom technique.

There is nothing difficult about any darkroom task. Practice and proper habits will prove this to you. There can be a great deal of work in the darkroom, and unless you develop the proper attitudes about working in the darkroom you can throw the whole clinic into a sloppy, muddled mass of confusion. Your NCOIC must have complete trust in your attitude and ability when you are working in a darkroom. He cannot allow poor workmanship because a film, that has cost time, money, and in many cases, pain, can be ruined in a second of carelessness.

Absolute honesty is required in the darkroom just as it is required in anything an X-ray technician does. It is important that when a technician makes a mistake he informs the personnel affected by it so the examination can be repeated. Each X-ray technician can and does make mistakes, but to lie or place the blame on someone else is not allowed. You will make mistakes at first, but you must learn from your mistakes so you will not repeat them. The darkness will not protect poor processing techniques from being seen.

## X-RAY PROCESSING

Let's say that you have just finished an examination in an X-ray clinic. You are going to develop and process your films now. Just how do you go about it? You have never been in a darkroom before.

## PREPARATION

In many clinics the darkroom technician is assigned for a period of a week in the darkroom. He is responsible for developing and processing all the film exposed in the clinic. He is responsible for keeping the darkroom clean as he performs all the tasks that are a part of the darkroom procedures.

Before the clinic begins business for the day the technician enters his darkroom. He will look about and make arrangements to prepare for the coming day.

Unless there has been a night man on duty he will check the dryers and remove all of the film that had been taken on the previous day. These films will have the corners cut and they will be matched to the proper request forms. He will check the temperature of his solutions in the developing tanks to see that they are at the proper temperature (Usually 68 degrees Fahrenheit). The developer solutions and the fixer solutions will be stirred with individual paddles. All available hangers will be replaced in their proper racks. The level of the solutions will be checked and if they are low, brought back to the proper level with a replenisher solution.

The technician will then turn out his white lights and check his film boxes to see that he has sufficient film for the day. If his film supply is low he will get more. The darkroom lights will be checked for leaks. After all this has been done he will remain in the room until his eyes have become adjusted. In many clinics the darkroom technician will wear a pair of darkroom goggles if he has to leave the room so he can keep his eyes adapted to the dark.

So as you can see, the room must be prepared. By doing all of these things in advance you can be prepared to meet the coming day. When each step has become a habit that you repeat day after day, you will have a smooth running darkroom.

## HANDLING FILM

Now that you have the darkroom ready, your first film is placed in the passbox. The passbox allows the outside technician to send film into the darkroom without entering.

When you open your film passbox, you will close the doors on the outside so the technician cannot open the box from the outside. The passbox is divided into two compartments; the right section is used for unexposed film, and the left section for exposed film. The technician must take care to avoid placing film in the wrong compartments. Misplacement of films may result in double exposures, thereby ruining two examinations, or developing film on which no exposure has been made.

UNLOADING. Unloading film is not a difficult task. If you have a cardboard holder just open the lid and envelope. Grasp the film with the right thumb and index finger at the bottom and with the left hand at the top. Separate the paper that is wrapped around the film and let it fall away. Then hang the film.

The cassette is placed so that the back is facing up. Press down on the fasteners and rotate them out of the locks. Be careful to press in the center and not get your fingers too close to the end. Some types of cassettes have a sharp metal edge and when you turn your fastener the fingers will slide along this edge and you will cut your-

self. When the cassette is loosened, hold it open with your left hand and remove the film. Grasp it from the lower right hand corner and lift it out. Be careful of crimping, bending or sliding it as this will cause static or crescent marks on your films. These marks are called "artifacts" and are not wanted on the film.

Before you go on, it must be understood that you will never attempt to load, unload or hang films with WET hands. When this work is done you must have dry hands and a dry surface. A wet surface will ruin your films and your holders. Wet hands will leave fingerprints on your films.

HANGING. After you have unloaded the holders, your next step is to hang the film. There are different sizes of hangers for each size of film you will use. These hangers are usually kept above the loading surface on racks where they are out of the way, but handy.

Once the film is out and you have the proper hanger, turn the hanger over till you have the bottom clips up. The film is hung from the bottom of the hanger first. Using the right hand you will clip the corner of the film into the hanger. Then turning the hanger in a clockwise direction you will fasten the other clips to the film. You will notice that the top clips have springs on them and can be brought down to the film. This allows you to maintain your film taut in the hanger.

If the hanger clips are filled with old emulsion these must be cleaned out with a steel wire brush so they will hold the film. When the springs are too loose, these must be readjusted to the proper tension. A hanger that is beyond adjustment should be turned in. If the hanger is badly worn, the films may bulge and touch one another in the solutions. If the hanger is worn out or not properly used you may ruin an examination. Hangers should be handled with care and not thrown around. One common practice in clinics is to remove films from a number of hangers by placing them together and punching or kicking them out. It is rapid, but it is hard on your hangers. Hangers should be removed from the film individually. It may take more time, but your hangers will last longer and operate better.

LOADING. Loading film is not a difficult task either, but it has to be done right. First, you must be careful about removing the film from the film box. It is very easy to remove two films or slide them against each other as they come out of the box. Once a film is removed from the film box or bin, CLOSE THE DOOR TO THE BIN OR PUT THE TOP ON THE BOX!

If you are loading a cardboard holder leave the paper that is on the film around it. Take the holder and open the lid and envelope and put the film in the holder with the open edge of the paper at the top of the holder. Cover the film with the top cover sheet and fold the side flaps in over it. Bring the bottom flap up and place the top cover of the holder down and clip it.. Inspect the holder to see if the envelope is worn or the flaps folded wrong. If your holder bulges there may be something improperly done. When your cardboard holders become worn they should be thrown away. Throwing your cardboard holders around in the darkroom or the passbox is detrimental to the film. Also do not pack them so tightly together you can't separate them without trouble. This packing will cause the films to have pressure marks on them.

The cassette will be loaded with the paper removed from around the film. If the paper is left the screens will not expose the film. Grasp the film at the right hand corner with the right hand and with the left hand separate the paper from the film.

Let the paper fall away from the film. Place the film in the cassette so that it doesn't stick out at the edges. Try not to slide it because this will cause static marks.

## DEVELOPING YOUR FILM

Once you have the film hung you will develop it. When you have a number of films to hang at one time be sure that these films are kept far enough away from the darkroom safelights and don't keep them out too long. Even in the darkroom they can become fogged. Do not unload more film than you can develop at one time. This will depend on how large your developing tank is; but if you can only develop five films, just hang five films.

When you have the number of films ready that you want for developing they are put into the developer one at a time. Keep them at least one-half inch apart. Make sure that the solution covers them completely. When you first put them in, agitate them. This removes any air bubbles that are clinging to the surface of the film. After they are in the solution set your timer.

The timer is a clock with a bell on it. Some timers are located on the developing apparatus and others are small individual clocks like your alarm clocks. They are called interval timers. You can set them up to sixty minutes, but ordinarily you will never use sixty minutes. Before you set the timer, however, you must consider a number of different things.

How warm or cold is the solution? What type of developer solution do you have? Is the solution fresh or has it been used for some time? Has the film been overexposed or underexposed? Is the film an emergency film?

TIME-TEMPERATURE METHOD. The time-temperature method is the technique that is used in developing your films. All of your radiographic techniques are designed so that after a certain time in a solution of a certain temperature the proper density is obtained on the film. The most common time and temperature used is 5 minutes at 68 degrees Fahrenheit. You will also use 3 minutes at 68 degrees Fahrenheit. These figures are the base figures. If your temperature is higher than 68 degrees you will reduce the time. If it is lower you will increase the time.

DEVELOPERS. Two types of developers are generally used for routine darkroom work. These are known as regular and rapid developers. They come to you either in a powder or a liquid form. Because these solutions are made by a number of different manufacturers it is wise to follow specific instructions provided by them for using the solutions. The regular developer is used at 5 minutes and the rapid at 3 minutes.

EXHAUSTION. Exhaustion of solutions occur as they are used. The amount of exhaustion can cause you to increase your time of development. It is important that you remember this fact. A solution that has had fifty films developed in it has suffered some exhaustion. The same thing is true with a solution that is a month old. Well, what can you do about it?

There are two methods you can use. One method is to keep track of the number of films that you have developed in a certain amount of developer. The other is the technique of adding replenisher solution to keep the developer up to normal strength.

FILM COUNT METHOD. The film count method will cause you to increase your development time after a certain number of films have been through the solution. This count is based on the number of 14 x 17 inch films developed in each gallon of solution. Most X-ray clinics have from 5 to 20-gallon tanks of solutions, depending upon the number of films they have to develop. A 5-gallon tank of developer will develop approximately 180 large films before it is considered to be exhausted.

If you can develop about 180 14 x 17 inch films, how many films of the 10 x 12 or 8 x 10 inch can you develop? You can figure that three 8 x 10 films will equal one 14 x 17 and that two 10 x 12 films will equal one 14 x 17. But, there is another factor that can complicate the picture. Some films are exposed more than the others so will require more action by solutions. A film with a great deal of its area exposed will exhaust the solution more than one that is not as dense. Just how do you determine, then, the exhaustion of your solutions? It is simple. When your films show unsatisfactory images you change it. This may occur with 100 films or 200. And, just how can you tell when the images are unsatisfactory? Time and experience are your teachers.

You must also consider that open solutions are subject to contamination. The solution should be kept covered because it can be oxidized by the air. Dirt and foreign matter can hurt your solutions. Solutions should not be allowed to drip back into the tank because as it passes through the air it is oxidized. As you remove films from the developer some of the developer is carried out. This reduces the level and you should never try to replace this level by dumping water from the rinsing tank into the solution. This will rapidly dilute your solutions so they won't be any good at all. The level is kept up by adding fresh developer that is usually mixed up and put into a separate bottle. This solution is poured or siphoned into the solution as it is needed.

If you use the film count method you will need to keep a good record. Accuracy of count is imperative if this system is used.

REPLENISHER METHOD. The replenisher method is more advantageous than the other. You do not have to keep records or adjust your time periodically. The replenisher solution is a concentrated solution of developer. It is used to maintain the level of the solution and its strength. Because the amount of exhaustion is determined by the type of film emulsion and film density, the amount of replenisher you will need to add will not be constant. Generally you will use it as the solution is lowered. Usually 3 ounces of solution is removed per film.

The films are removed from the solutions rapidly and are not allowed to drain back into the tank. The solution can be used until it has been replaced with about three to four times its volume in replenisher or until the films become unsatisfactory. Even with this standard it will probably be changed at least once a month. All of these things will be variable due to contamination from other sources, film density and emulsion types.

SIGHT DEVELOPING. Sight developing is a practice that should be performed only at certain times. It is not advisable for the general routine development. It is used when you know that the films have been accidently or deliberately overexposed, or when a film has been exposed more to increase the speed of processing it. Because the eye is not adapted readily to the dark the film will look all right in the darkroom. But when it is seen in the light it will lack the density you thought you saw in the darkroom. Also the raising and lowering of the films in and out of the solutions

will cause them to be unevenly developed. Inconsistency will occur if each film is sight developed. This is caused by some films being in the developer longer than others.

Now that you have some idea of the various factors that will determine your time you can see it isn't just a time-temperature technqiue. The technique will be the base from which to start, but you must also apply the type of solution, age of your solution and the amount of contamination present to your decision.

## WHAT IS HAPPENING IN THE DEVELOPER?

You've been learning quite a bit while your film has been in the developer. Let's hope that it isn't fogged too badly. This is what happens when you go off and forget you have a film in the developer. You will hear that a film, if it is properly exposed, does not develop beyond those crystals that have been effected. However, it will be subject to chemical fog if left too long in the solution.

You should have some knowledge of what reactions are taking place.

Four basic ingredients make up the developer solution. To develop anything you have to have a developing agent. In your developer you have two developing agents. These agents are called elon and hydroquinone. They must be used together because each produces a specific result. The elon brings out the soft warm tones in a radiograph. The hydroquinone brings up the sharp contrast. If they were used individually the elon would produce a film with indistinct contrast and the hydroquinone would show just a harsh black and white. With a combination of the two the middle tones are brought out.

Because of the oxidation of the developing agents the solution has to have some kind of a preservative to delay this. Sodium sulfite is the chemical used. It absorbs the excess oxygen and makes the solution last longer.

The gelatin on the film must be reached before the developing agents can get to the exposed silver bromide cyrstals of the film. Penetration of the gelatin is accomplished by what is known as an accelerator. The chemical used is sodium carbonate or sodium hydroxide. This makes the gelatin swell so it can be reached by the developing agents. Thus it accelerates the developing process by letting the other chemicals get to the crystals.

Now the developing agents can become a little careless in their selection of crystals to work on. To keep them on the right track so they will work only on the exposed silver bromide crystals a restrainer is added. This is potassium bromide or potassium iodide. By restraining the developing agents from over acting, fog is inhibited. If the film is left in too long the restrainer cannot completely stop the fogging action.

Now you know what is happening to your film. You have been told to agitate the film to remove the air bubbles. If you don't the developer doesn't reach the film and those areas will not be developed or they will not be developed as much as they should have been. Your film will look spotty. Also agitation is necessary to keep fresh developing agents near the surface of the film. The bromides that are reduced out will form a barrier to the other agents. When the film is shaken up and down these bro-

mides are driven away. You should agitate your films at least once a minute during the developing process.

The temperature of your developer will affect these chemicals. If the solution is warm the chemicals will react faster. When they are cold they won't work as fast. As has been stated, the ideal temperature is 68 degrees. If your solution is below 60 degrees the elon and hydroquinone do not react properly and your film will be improperly developed. The range of temperatures you should use is between 65 and 75 degrees Fahrenheit. Time adjustments must be made, however, if there is a variation from 68 degrees.

## RINSING YOUR FILM

When the designated time of developing is over, the films are taken up smoothly and placed in the rinse water. The solution should not be allowed to drain back into the tanks. The films should be rinsed about 30 seconds so most of the excess developer is not carried over into your fixer tank.

## FIXING YOUR FILM

Your fixing or "hypo" solution is contained in a 5 to 20-gallon tank. This solution does a number of things. It stops further development, hardens the emulsion of the film and removes all of the unexposed silver bromide crystals. The film is still green in many places right after you take it from the developer. These green areas are unexposed silver bromide. The development process reduced the other exposed crystals to black metallic silver.

How does your fixer solution work? Like the developer, the fixer solution has four basic ingredients. These are a fixing agent, a preservative, a hardener and an acid. The fixing agent is sodium thiosulfate. Its job is to dissolve the unexposed silver bromide crystals out of the film. It will take about 2 to 3 minutes after the film is inserted in the fixer to clear it. The white lights should not be put on until the clearing action has taken place.

The preservative, as in the developer, is a sodium sulfite. It keeps the sodium thiosulfate from decomposing and inhibits the discoloring of the fixer. The hardener is usually chrome alum or potassium alum. The emulsion was softened in the developer and this chemical hardens it again so it won't scratch.

The acid is used to neutralize the alkali from the developer. The developer is an alkaline solution. Sulfuric acid or acetic acid is used to counteract the solution that is brought into the fixer from the developer. The acid provides the medium in which the hardener and the fixing agents work.

The fixer solution is exhausted when it takes a prolonged period for the films to clear. You should agitate your films in the fixer too. This will prevent any streaks that could come by uneven clearing. Its temperature should be the same as the developer. Sometimes you are required to get the film to the doctor as soon as possible so if you give the film vigorous agitation it will be cleared sooner.

A film is not properly fixed when it is just cleared. The hardening action pro-

vides the film with a long life. An X-ray film should have at least five years of useful service. To insure that it has sufficient time to harden, keep the films in the fixer for at least twice the time of development. Generally in Air Force clinics the films are fixed at least 15 minutes. An improperly fixed film will contain crystals which can be exposed to light or be soft so that chemical action continues. This will cause the film to discolor and fog.

## WASHING YOUR FILM

The film is washed in clear, running water from 20 to 30 minutes after fixing. This is necessary to wash away all of the chemical that has clung to the surface of the film. Unless they are washed sufficiently you will have fixer stains or streaks on them. Prolonged washing tends to make the emulsion soft so don't keep them in too long. Many technicians do leave films in the water overnight, but try to avoid this if possible. The water should be the same temperature as the other solutions. If the water gets hot the emulsion on your film will melt off. This results in a big cleaning job.

## DRYING YOUR FILMS

In most Air Force clinics, you will use a heated dryer to dry your film. These dryers have a heating element and a fan to circulate the air. The clinics will present a variety of different types, but they all work on the same principle. You will find that there will be times when you will have to dry your films in rooms or out of doors. The disadvantage of outside drying is the chance of getting the films covered with dust and dirt.

One precaution you will need to take when you use the dryer is not to swing wet films over partially dryed film. This will cause water spots or streaks on the film as the drops splatter the films. On the film these spots sometimes resemble rarified densities and can lead to a bad diagnosis. This artifact is easily avoided with a little attention. Also be sure that all of the films are far enough away from each other that they don't stick. It is practically impossible to separate two films stuck together in a dryer. This same precaution must be used in the developer, fixer and wash as well.

The time of drying will depend on how efficient your unit is. If the time is excessive the unit should be fixed. A film will normally dry in forty-five minutes to one hour. The only area that will give you any trouble will be the point where the clips hang the film. Water sometimes remains there because the air is not readily circulated around it. This can cause water spots if you do not remove the films from the hangers very carefully. Wet fingers on dry film will cause fingerprints.

## CORNER CUTTING AND MATCHING

You have now developed, rinsed, fixed, washed and dried an X-ray film. Now if you will find a film in the dryer you will see that when it is removed from the hanger the corners have sharp jagged points. These have to be cut off so that they will not scratch the films. After the corners are cut the film is matched against the request form. Together they go to the radiologists who read them.

# YOUR DARKROOM

There are many different types of darkrooms. They will range from a 4 x 4 foot room to elaborate two and three room facilities. You may be working with improvised tanks or automatic units. In any of these, however, you must have a place to develop, rinse, fix, wash and dry the film.

Information on all the various types of techniques and equipment available could not be included in five volumes on darkroom techniques or equipment. But you will learn about some of the equipment you will use. Also you should know how to care for and test some of this equipment.

## DARKROOM LAYOUTS

Darkrooms are constructed so that they are fairly close to the radiographic rooms. The primary purpose of a darkroom is to keep the films in safe light while they are being processed. To insure that light does not enter a darkroom accidently there are a number of systems used to enter the darkrooms. The entrance is known as a "maze". In the beginning the maze was a series of wall panels arranged to keep light out. They resembled a psychologist's maze for testing the ability of mice to find their way out of a closed unit. A number of these mazes still exist in Air Force clinics. A system of double doors is now used in many clinics. You open one and enter a dark ante room. Closing this door, you can enter the darkroom with either a signal or a knock. Some darkrooms have automatic door locks or lights over the entrance so you can see when it is safe to enter a darkroom. Some rooms have just a GI blanket tacked up over an open door. The main purpose is to keep light out. Your responsibility is to be sure that you do not enter a darkroom until you are sure that films will not be exposed.

In your darkroom you will need a loading bench. This will be anything from a field table to a built-in cabinet. Your films are kept in the boxes that they come in or in film bins. You will need a film processing tank which has a place for developing, rinsing, fixing, and washing. These are found as separate units and as combined units. And you will need some place to dry your films. Usually you will have drying equipment, but you will also find a variety of homemade racks for open air drying.

## DARKROOM SAFELIGHTS

Any light will affect your films. Some of the films that you will use will require that all the lights be out. In your darkroom you will have a safelight. It is safe only for the type of film that you are going to expose to it. X-ray film is manufactured to be sensitive to a certain type of light. Because the light from the screens are primarily in the blue wavelength any safelight that would allow blue light to reach the film would ruin it. This means that you could not use a blue filter over a white bulb because it would only allow blue light to pass through it. However, if you have a filter that will block out blue light your film will be relatively safe.

Most of the darkrooms that you will be working in have red or yellow-green type of filters over the white bulbs. This will be satisfactory for everything except photofluorographic film.

Even with safelights you must be careful about fogging film. The bulbs that you use in your safelights should be from 6 to 15 watts. The wattage will be dependent on the manufacturer of your safelight. You should check your filters for cracks that will emit light. After a filter is aged it will crack. The usual filter supplied by your medical supply will be a Wratten 6B filter. This is a Kodak filter.

Other factors can cause fogging of your films. One is the distance that you have the light from the film. Another is the length of time that your films are exposed to the light. A film that has been exposed to X-ray is MORE sensitive to the safelight than one that isn't exposed. Screen type film is more sensitive than non-screen film.

So what can you do to find out how safe your lights really are? It is a simple procedure. Try an experiment with each type of film that you are using in your department. Expose one set to X-ray and place it beside a film that hasn't been exposed. Take the film to the bench where you load your films and cover them so that various areas can be exposed periodically. Expose each area to the normal safelights you are using. Start with a one-half minute and then progress through 1, 1-1/2, 2, 2-1/2, 3, 3-1/2 minutes. Cover each area that has been exposed so it can't be exposed again. Then develop the film. Look at the film and the point where you begin to see the first fogging effect indicates the time that is safe for your film to be exposed to the lights. Try this at various distances from the safelights - 18", 30", 36", 48". You will probably find that the farther away you have the film the longer it will take for it to show signs of fogging.

You were told that you should only hang as many films as you can develop because of the danger of fogging them with safelights. Because your films have now been exposed to X-ray they are even more sensitive.

Many clinics will not have sufficient number of cassettes or hangers, so it will be necessary to place undeveloped film in a film box to be developed when you have time.

## CONTROLLING TEMPERATURES

Some of your equipment will have the feature of temperature control, and some of your equipment will not. You will work with completely automatic controls and with plain hot and cold water faucets. In some field equipment you may not even have the faucets. A standard item of equipment will be a thermometer. This thermometer will have a weighted end which allows it to float in the solutions. In the larger combination tanks the water is regulated automatically. The tanks of solution are inserted in the water and the temperatures are regulated by the water bath. Look at your darkroom and see what type of temperature control you are using for your processing solution.

Room temperature and humidity must be controlled also. Because your films and solutions are sensitive to temperature conditions the room temperature should be controlled wherever possible. An airy, well ventilated darkroom is a necessity.

## FILM STORAGE

Although many clinics do not store films directly in the darkrooms you should

have an idea of the best means of storing them. You do not lay your films on top of each other. This will produce pressure marks before you even open the box. The films must be protected from stray radiation. Most darkrooms are leadlined so this isn't generally a problem in the Air Force. They should not be placed in a warm or moist place. You should use films that have the earliest exposure deadline first. For example, on a box of film you might find a notation that says, "Expose before 22 Jun 58". This means that these films should be used before that date for the best results. You may not have any bad effects, and then again, you may find that the films aren't providing the best images.

Once a package of film has been opened care must be taken to insure that the unexposed film is stored in a light tight container or film bin. This may seem like simple advice but it costs the Air Force many dollars each year because lights were turned on near open boxes or bins.

## CARE OF SCREENS AND CASSETTES

Cassettes are expensive and very useful in X-ray clinics. Although they are strongly built they should not be carelessly abused. Dropping or packing them too tightly will warp the frames or crack the bakelite fronts. Abuse will allow the hinges to be worn or the felt packing around the edges to be removed. All of these things will admit light through leaks which make them useless. Handle them with care.

### CLEANING SCREENS

Cleaning screens is a task that many clinics perform periodically. A cassette should be inspected periodically for dust, grit, stains, scarring or poor screen contact. When a film shows a number of white spots or fuzzy areas your cassette needs cleaning and the screens adjusted.

Mild soap and water is used to wipe the screens free of dust and dirt. They are then rinsed with a damp cloth to remove the soap. Do not pour a great amount of water into your cassette. Use only a slightly dampened cloth. The screens should be dry in a few minutes if you have not used too much water. Be sure they are dry before you reload them with film. In many instances you can brush off the dirt and lint on the felt lining with a soft lintless cloth or a camel's-hair brush.

Screens of the "PATTERSON" brand can be cleaned by wiping the surface with 70% ethyl alcohol that is not denatured. Do not use alcohol on any other screen unless recommended by the manufacturer. Be sure that no denaturing chemicals have been added to the alcohol.

The amount of cleaning required will depend upon the place you are stationed. If you are near a populated center with industry close by or out in the middle of a windy, blowing desert you will need to clean your screens more often. It is recommended that the screens be protected from light, dust, or stains by keeping the cassette closed after you take the film out of it.

It is a common practice in X-ray clinics to number the cassettes so they can be

identified when artifacts are noted. This is usually done by numbering the screens with India ink. Care must be taken when washing your screens so as not to smear the ink. After the screen has been cleaned, a label or notation on the back of the cassette will indicate the date and what was done to the cassette.

## TESTING FOR SCREEN CONTACT

In your chapter on radiographic technique you learned that intensifying screens must be in close contact with the film. If they are not there will be a fuzziness to the image. You may find this only in certain areas of the film. There is a way to test for screen contact with which you should be familiar.

In testing the screens for contact take a loaded cassette and place a 1/4" or 1/16" mesh wire screen on top of it. The mesh screen should be the size of the cassette. Make sure the mesh is lying flat on the film. Expose the film. Develop the film to see if the image of the wire is sharp. If it isn't the screen contact is poor.

What do you do if the screen contact is poor? You must find some means of restoring the proper contact. This is done by remounting your screens in the cassettes.

## MOUNTING SCREENS

Your intensifying screens will come in sets of two. You will find one screen is thicker than the other. The thin screen is placed on the bakelite front of the cassette, the thick one on the back or lid. You will need screen mounting tape, ether or some solvent to wipe away the adhesive of the old screens, and a flat spatula. The old screens are removed from the cassette. Care must be taken that the felt on the back is not removed or pulled away. The cassette is cleaned with ether to remove the old adhesive. While using the ether do not allow flames or smoking near the work area. Sometimes carbontetrachloride is used so be sure that the room is well ventilated. The mounting tape has adhesive surfaces on both sides so it will stick to the screen and the cassette. It will usually be a Scotch brand 400. It is a quarter-inch tape resembling masking tape. Care will be exercised when you place the tape on the back side of the screens again when you place the screens in the cassettes.

Once the screens have been replaced in the cassettes, each cassette should be tested again. If there is still poor screen contact the area can be built up with layers of tissue paper until the proper contact is made. This can be a tedious operation, but it is a necessary one. You will find that the addition of paper under the poor areas will not be required often.

# DARKROOM MAINTENANCE

Maintaining a darkroom so that it will function smoothly is an important task for the X-ray technician working in it. The cleanliness of the equipment will determine how well your films will turn out. The thoroughness with which the solutions are mixed and maintained will also be shown by the films processed in them.

## MIXING YOUR SOLUTIONS

You have read about how the developer and fixer react on the film. Your next step is to learn how to mix these solutions. You will probably mix both the powder and the liquid forms. The liquid is more easily prepared.

Two separate paddles should be used, one for the developer and one for the fixer. The solutions should be mixed in non-corrosive containers such as glass bottles or stainless steel buckets. When mixing you can use the tanks themselves. After the solutions are mixed the paddles are washed in clear, warm water. This will prevent the solution from drying and the material from being deposited about the room as dust.

Directions for mixing the solutions are contained on the cans or bottles. The chemicals may be produced by different companies, so it is best to follow the instructions provided by the company whose product you are using. Generally, the developer will come in two containers. A small container will hold the developing agents. The larger will hold the other chemicals. Contents of the larger container will be mixed into water slowly and then the contents of the small container will be mixed into this solution. If the chemical is a powder, you must pour it slowly while you are stirring it. This will allow thorough mixing and prevent lumping of the chemicals in the bottom of your container.

With the solutions at a temperature above normal using range, it will be necessary to let them cool or add the remainder of the water necessary at a temperature which will bring them to level required. Usually chemicals are made at the end of a day or early enough to be able to use them. The temperatures that are recommended should be used. Usually these will be in the range of 75 to 85 degrees. If they are not mixed properly the solution will have a milky appearance which will usually clear after standing for a while.

The liquid solutions are easier to prepare at working temperatures. These can be mixed near the developer temperature used and will eliminate the period of waiting. Don't use ice to cool solutions unless it is an amount equivalent to the amount of water you would need to bring your solution into a proper mixture. When preparing fresh solutions, it is suggested that you prepare an extra amount to use as a replenisher.

## DARKROOM CLEANLINESS

Because dirt, spots or stains adversely affect your films, your darkroom must remain in a very clean state. Also because your chemicals can corrode your equipment, it is of importance that the darkroom be kept wiped and clean. Your health is of importance too, so the darkroom must be well ventilated.

The habit of wiping solution tanks each time they are used is something that will save you much work later on. If the solutions are allowed to dry, they will blow about your darkroom as dust and get into screens or on films. Excess gelatin on hangers will cause these hangers to hold chemicals which will streak the films. Your dryers should be kept clean of all dirt and corrosion. Cleaning will be a day-to-day task and must be taken care of at the end of each day. A dirty dryer will circulate dirt and dust which will stick to your films.

Algae may form on the surfaces of insert tanks and on the walls of the master tank. The algae should be cleaned off with a stiff GI brush. An accumulation of algae will stop up the flow drains.

Water must be kept off the floor. This is to protect you from electrical hazards and slipping, as well as to provide a good environment in which to work. All waste paper and materials should be removed each night to avoid the possibility of fire.

An X-ray technician must be clean ANYWHERE ..... in person, darkroom or clinic.

## SPECIAL PROCESSING TECHNIQUES

There will be times when you will be required to develop films faster than the normal pace. This is true when you work in the operating room. You can use a number of different techniques to examine a radiograph quickly.

One simple method to use, when time is limited, is to increase your exposure by doubling your MAS and reducing your developing time in half. There would be some sacrifice of quality, but this is to be expected using this method.

Another method is to increase your exposure about 40% and then develop your film in a concentrated solution for about 30 seconds. The concentrated solution consists of one part of the solution to one part of water. Continually agitate your film. Have the temperature of your solution at about 80 degrees Fahrenheit. When using a method such as this you should have an "acid bath" available. Because the emulsion of the film is swelled more, more developer reaches the crystals and will be held there. An acid bath of 1.5% acetic acid solution will neutralize the excess developer. The film is then placed in the fixer for about one minute until it clears. After the film is cleared, agitate it for about 5 seconds in the wash. It can then be viewed. After viewing take the film back and replace it in the fixer to harden.

## BEHIND AND AHEAD

You should know how to use a passbox; unload and load film holders; hang film; check temperatures of solutions; develop film using time-temperature method; what takes place in the developer; and the need for agitating films in this solution. You have learned the techniques for processing and checking your films. You are familiar with the importance of keeping your darkroom clean. And you know some means of developing films rapidly.

Ahead of you will be a chapter on special procedures and techniques. These procedures will be some that you will see done most frequently in your clinics. There are a great number of special procedures, but the Air Force X-ray technician will only be called upon to perform a few of them routinely.

The special procedures that you will study will pertain to the visualization of the

various systems of the body. Because these systems have a similar density, a medium must be administered that will outline these organs. You will learn what medium is used, how you prepare it and the patient, what your duties are, what positions you will use in radiographing these systems, and a general summary on why the examination is performed.

The special techniques are techniques that use the physical principles of your machine and the beam. It will include stereography, foreign body localization, body section radiography, pelvimetry, fluoroscopy, photofluorography, scanography, etc. These terms will become more meaningful as you read the next chapter.

It will be wise to remember that some of these examinations are not done in a number of small clinics. They will be modified from clinic to clinic and doctor to doctor. You must learn new ways of doing them. It will take time and opportunity to become proficient in performing special procedures and techniques. You will encounter various auxillary equipment used in these examinations which you must learn to operate. Although most of this equipment operates on the same principles, you will meet many modifications in the operation of the various makes and models.

The one thing to remember is to learn well the procedures and how to operate the equipment that you actually have in your clinic. If you do not have the equipment you cannot expect to learn some of the procedures performed with it. As you meet new procedures and equipment add them to your background of knowledge.

## WORK PROBLEMS

1. Practice unloading, hanging, and loading with a film in the light. Then turn off the light and get the feel of doing it in the dark.

2. Mix up a gallon of developer solution and put it in a stoppered bottle. If you do not have a developing tray see if you can borrow a stainless steel container from central supply large enough to hold an 8 x 10 film. Place your solution in a sink where you can change the temperature of the solution from cold to hot. You can get ice from the hospital dining hall and use the hot water faucet. Make some experimental exposures using the same technique for all of them. Bring the solution temperature down to 55 degrees and develop the first one, use 60, 65, 68, 75, 80, and 90 degrees. The exposures could be made on strips of film to prevent waste. A finger would be enough for a part. After they have been developed look at them and see what has happened to them.

3. Perform the following simple experiments. Use strips of films.

   a. Using normal techniques, develop a film for ten minutes and another one at the regular time. Use the proper temperature.

   b. Develop one film using the time-temperature method and another one with sight developing.

   c. Develop a film and then swish it around in the fixer for a few seconds. Look at the film.

d. Fix a film long enough to clear it and then hang it up without washing it.

e. Take a film and slide it over the loading bench. Develop it.

f. Bend a film sharply and then develop it.

g. Dip your fingers in water then hang a dry film. Let it dry and then develop it.

h. Take a strip of film and follow the processing procedure, but then hang it in front of a hot bulb or heater.

i. Take a dryed film without the corners cut and run it over another film.

j. Put a film in water and leave it for a day or so. Then run your fingernail over it.

k. Take a partially dryed film and flick water at it until you have spots and streaks on it. Let dry completely.

4. Take a film out and then flick the lights on and off quickly one time. Develop it.

5. Place the film in the tank and then open the door so light can come into the darkroom for an instant.

6. Place a film in a cassette with the paper around it. Expose the film and then develop it.

7. If you have some old intensifying screens and an old cassette try some of the following experiments.

   a. Fleck out a spot of the emulsion with your finger. Take a radiograph and develop it.

   b. Pour a drop of developer on the screen and let it dry. Take an exposure and develop it.

   c. Sprinkle a bit of dust on the screen. Place a film in the screen and expose the film. Develop it.

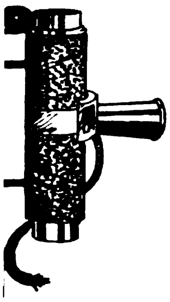
   d. Take some denatured alcohol and place it on the screen. Let it dry. Take a film and place it in the cassette. Expose it and then develop it.

8. Perform the experiment given you in the chapter to test the safelights in your darkroom.

9. Using an old cassette and screens, practice mounting the screens.

## QUESTIONS

1. Explain how you load and unload a cardboard holder.
2. How do load and unload a cassette?
3. How are static and crescent marks made on your films?
4. What do air bubbles do to your films? How do you remove air bubbles from your films?
5. Explain the use of the film count method in keeping track of solution exhaustion.
6. What three things must you consider in selecting the proper time for developing your films?
7. Explain the use of elon, hydroquinone, and sodium sulfite in darkroom work.
8. Why should film be rinsed?
9. Give three functions of a fixer solution.
10. Explain the use of sodium thiosulfate, chrome alum, and sulfuric acid in a fixer solution.
11. How long should a film be placed in the fixer?
12. How long should you wash your films?
13. How long do you dry your films?
14. What are some examples of mazes?
15. Name five different articles of equipment you will need in your darkroom.
16. What color of filter will you normally use in your darkroom?
17. What should you do if you have to remove more films from your holders than you can develop at one time?
18. How is the temperature of your solutions controlled?
19. Explain how you test for screen contact.
20. After the screens are mounted, how do you check to see if you have them mounted correctly?
21. Why are two separate paddles and buckets needed for mixing solutions?
22. What are the advantages of liquid developer and fixer solutions?
23. Explain some methods for developing films rapidly.



# CHAPTER 9

## SPECIAL PROCEDURES

Besides the routine examinations of the skeleton, the X-ray technician is called upon to demonstrate various body systems or parts of the systems. He also will perform special diagnostic examinations or use special techniques which reveal more specific information than do routine radiographs. These special procedures and techniques require special materials and equipment which you must learn to use. Many of the procedures are done by the doctor, but the technician must learn the examination so that he can anticipate the doctor's requests. Experience is a very necessary factor in these examinations so you must seek every opportunity to help in performing these procedures.

The methods of doing these procedures are greatly varied. In the Air Force there are many clinics that do not have the equipment or a radiologist to perform these special techniques or procedures. Because of this fact many technicians feel insecure about their ability when they are transferred from clinic to clinic. This insecurity is unnecessary because at each clinic you will learn the techniques that they use for these procedures. There is nothing mysterious about them and the average technician can learn to perform them with practice. It is important, however, that he be very conscientious in developing the teamwork that is necessary. The types of examinations you will perform will largely depend upon the size of your hospital and the number of doctors working in your hospital. Where there is a neurosurgeon you may be called upon to perform ventriculography and myelography.

The techniques and procedures given in this chapter are those that are done the most frequently in the Air Force. Thus, you will see the examination of the gall bladder, the intravenous pyelogram, gastro-intestinal series, esophagrams, barium enemas, retrograde pyelograms, cystograms, bronchograms, cholangiograms and hip nailings.

You will learn about hysterosalpingography, sialograms, penumoperitoneum examinations, myelograms, vasograms, ventriculograms, pneumoencephalograms, abdominal arteriograms, angiocardiograms and cerebral angiograms.

You should also be prepared for many modifications of these techniques and procedures. With new advancements being brought to the field and development of

new contrast media you may find it necessary to change old methods. You are not expected to possess the knowledge of the physician or radiologist, but you will be a better technician if you keep up with the literature on these procedures. Before you start on these procedures you will need some basic knowledge of fluoroscopy and contrast media.

## FLUOROSCOPY

Fluoroscopy is one of the tools that is used in the examination of the organs in the body. X-rays are passed through a patient and activate a screen. The thinner parts will allow more of the beam through to the screen. Thus you have a shadow of the organs where the beam does not penetrate as easily. Now, the body which is in front of the tube, is living and the organs of that body are moving in their natural motions. You can see the living motion of the heart, stomach, intestines, etc. You can observe the heart beating, the act of swallowing and the passage of media through the stomach.

Fluoroscopy is used to show these normal movements, to locate abnormal movements or functions, the shape of organs, and also to check the path of filling organs with contrast media. There is also a combination of fluoroscopy and radiography. Sometimes an examination will consist of both fluoroscoping the patient and then recording some of the things seen during the fluoroscoping on radiographic film. Or after fluoroscopic examinations there will be a series of films made which provide a permanent record that can be studied at leisure.

### FLUOROSCOPIC EQUIPMENT

Most machines have fluoroscopic apparatus attached to them. The fluoroscopic apparatus consists of a fluoroscopic tube that can be placed under the table; a shutter device with lead diaphragms to restrict the size of the beam; a fluoroscopic screen; generally a spot-film device; diaphragm and spot-film controls; a foot control switch and a fluoroscopic circuit within the control panel of the unit. Also a tilting X-ray table is used.

FLUOROSCOPIC CONTROL. The fluoroscopic control on the panel is the radiographic-fluoroscopic switch. This switch will place the machine in operation for fluoroscopy. The circuit will automatically place the unit on fluoroscopic MA readings. Your fluoroscopic timer is an intermittent timer and you can set it for five minutes on most machines. This timer can be started and stopped by pressing or releasing the foot switch. It safeguards the patient from over exposure to radiation. Most fluoroscopic timers will automatically cut off after five minutes. The radiologist will control the foot switch and view the body in short exposures. When the unit is set for fluoroscopy the white lights on the control panel will go out and only a very dim light will be used to read the meters. If there is a spot-film device attached to the unit, the control will automatically set this on a certain MA and radiographic time. This MA may be 50, 100 or 200 depending on the machine that you are using. When the spot-film device is brought into play, the unit automatically switches to radiographic techniques.

**FLUOROSCOPIC TUBE AND SHUTTER.** The fluoroscopic tube provides the X-ray beam, and shutter devices limit this beam to the size of the fluoroscopic screen. The controls for the shutters consist of knobs, twist handles, levers or buttons. The tube is underneath the table and the diaphragm is placed directly over the tube. The tube is connected directly on a fluoroscopic carriage, with the screen, so that when the screen is moved the tube will move also. At other times it is desirable to have independent motion of tube and screen. There are locks on these combinations which will allow you to secure them when necessary.

**FLUOROSCOPIC SCREEN.** A fluoroscopic screen works on the same principle as the intensifying screen in the cassette. It is a cardboard sheet coated with an emulsion of cadmium zinc sulfide crystals. These crystals emit a yellow-green light when they are activated by a beam of X-rays. The screen is placed behind a lead glass window for protection of the radiologist. The glass will allow the light from the screen to pass through, but will stop the X-ray. You will usually find a grid behind the screen to eliminate secondary radiation. These fluoroscopic screens should not be exposed to white light or sunlight because they will lose their ability to fluoresce.

**SPOT-FILM DEVICES.** Spot-film devices are used during fluoroscopy to obtain radiographs of the organs. The radiologist will see something that he would like to study further and make a permanent radiograph of it. You will find that you can take from one to four radiographs with most spot-film devices. By arranging your film in a certain manner your doctor can select the number of exposures he wants to take. He may see something and take one exposure, then fluoroscope again and take another. Or he may just take one, two, three, or four exposures without fluoroscoping in between.

Providing film for the spot-film device is one of the technician's duties. You will place the cassette into the device with the back facing you. Remember that the tube is facing the doctor with the patient between them. The cassette must be securely snapped into the unit or you will jam it. Also the doctor will not be able to use it at the instant he wants it if you have to pick up a dropped film or readjust it. Practice in the dark if necessary so you can do it by feel.

You find a number of different types of spot-film devices. Some are automatic and in others you must shift the film yourself. Behind each screen, as you bring the spot-film device over in front of it, you will see a round cone projecting from it. The cone is placed in the middle of a sheet of lead so only the cone area is radiographed. This exposed area is a cone field or "spot". The lead also protects the film during the fluoroscoping procedure.

## FLUOROSCOPIC TECHNIQUES

Fluoroscopic techniques are used with the view of providing minimum exposure with maximum lighting of the screen. The technique that is used by technicians will be from 3 to 5 MA at 85 KV. The doctor will usually tell you which MA he prefers to use. You will find a fluoroscopic MA selector on your control panel. The spot film device will be on the radiographic circuit when it is used. The time of exposure should be carefully checked on your tube rating charts so you will know the capacity of your tube. With low MA used in fluoroscopy, continuous exposure is a common practice in modern day equipment.

## DARK ADAPTION

Dark adaption for fluoroscopy is an important part of the preparation for the examinations. Because the fluorescence of the screen is rather dim, the doctor should have his eyes well adapted to the darkness. If he comes in directly from the light he cannot see the image as well. Generally he will wear a pair of red filter goggles for 30 minutes before the examination is to begin. The technician usually does the same thing.

The room is darkened during fluoroscopy and care must be taken that no one inadvertently opens a door while the examination is being done. Usually you will have a red light connected to the circuit which will provide enough light for you to move around.

## DUTIES

Your duties during fluoroscopy will be to prepare the media for the radiologist and assist him as he requires it. He will be doing most of the actual work. You will keep him supplied with film for his spot-film exposures and bring the patient media, etc. You will prepare the patient and equipment before the examination begins. You will position and take films after fluoroscopy.

## PROTECTION

Protection in fluoroscopy is very important. Of course, the patient will be subjected to more radiation than he might ordinarily receive with conventional radiographs. The tube is placed in the equipment so that it is at least 15 to 22 inches away from the patient. The lead diaphragms help to restrict the beam. At least 1 mm. of aluminum is used to filter the beam. It has been found that use of 3 to 4 mm. of aluminum will allow the use of higher KVP's but this is a matter for your radiologist to decide. Also the patient is further protected by the automatic interruption of the exposures.

The technician wears a lead rubber apron and DOES NOT STAY IN THE ROOM DURING EXPOSURE ANY MORE THAN NECESSARY. <u>AND HE NEVER ATTEMPTS TO PERFORM FLUOROSCOPIC PROCEDURES.</u> The only time that he must be in the room is when he is actually helping the doctor.

The doctor is provided with a lead apron and lead gloves. A fluoroscopic chair is provided with a lead sheet protecting him as he sits. The lead glass of the screen provides further protection.

Detection devices are worn at all times in the clinic and especially when you are working in fluoroscopy. Doors should be locked to avoid entrance of people into the room - both for protection from exposure and to exclude light.

Now that you know something of fluoroscopy you will need to know what contrast media is and why you will be using it.

# CONTRAST MEDIA

A contrast medium is any material which will cause the soft tissue systems of the body to be outlined. This medium can be either heavier than the surrounding areas or lighter than the areas next to it. Just as you have a contrast between the white bone and the grayer appearing skin, you will need contrast between one organ and the others.

Before contrast medium was developed the only means to see a diseased organ was to perform an exploratory operation. Now the organ can be studied without cutting into the body. By having the patient swallow barium sulfate solutions the radiologist can study the esophagus during the act of swallowing. He can watch the barium enter the stomach and watch the stomach work. If there are ulcers, he can see where they are located and how large they are.

## FORMS OF CONTRAST MEDIA

Contrast media can come in many forms. They can be liquids, powders, gases or pills. There are different types of contrast media made to examine specific areas or organs. Some of these will localize into only one organ.

Contrast media are given intravenously, drunk in the form of liquids, taken orally in pill form or injected as an enema. Gases are injected with needles or tubes into the spaces to be examined.

## CONTRAST MEDIA USED IN THE AIR FORCE

Contrast media are known by trade names or by chemical names. Those that are standard supply items are requisitioned by chemical names. A number of the media used in the Air Force are bought by local purchase. Listed below are some of the contrast media used in Air Force Clinics. The brand or type of medium used will depend upon your doctor and the type of special procedures that your clinic will be doing.

- Barium Sulfate
- Urokon (Sodium Acetrizoate)
- Diodrast (Iodopyracet)
- Skiodan Sodium (Methiodal Sodium)
- Lipiodal
- Salpix
- Telepaque (Iodopanoic Acid)
- Priodax (Iodoalphionic Acid)
- Cholografin (Sodium Iodipamide)
- Neo-Iopax (Sodium Iodomethanate)
- Pantopaque
- Iodochloral (Chloridized Oil)
- Teridax
- Dionosil
- Hypaque (Sodium Diatrizoate)
- Renografin
- Neo-Sapax
- Mioken (Sodium Diprotrizoate)

## CONTRAST MEDIA REACTIONS

Although the majority of your patients will show no reaction to these various contrast media, there will be some patients who will develop reactions. These symptoms should be recognized so that you can inform your doctor quickly. Usually he will be constantly available during the administration of a medium. Some reactions of media are common, such as slight feeling of nausea or a feeling of heat. You should tell your patient that these feelings are to be expected so that he will not become fearful as he experiences them. Some of the more common type of reactions are listed below.

- Nausea
- Vomiting
- Heat
- Flushing
- Urticaria (Hives)
- Faintness
- Excessive salivation
- Headache
- Diarrhea
- Bitter Taste
- Hypotension
- Convulsion
- Arm Pain
- Chest Pressure
- Chill
- Dysuria
- Cough
- Weakness
- Thirst
- Wheezing

Many of the contrast media have iodine in them. Iodine has a high atomic weight, and because of this fact, is opaque to X-rays. However, some people are sensitive to iodine preparations and must be tested to see if they can tolerate the medium given. This is done by a sensitivity test before the medium is injected into the system. A small quantity of the medium is injected under the skin. If after 5 to 10 minutes there is no sign of sensitivity the medium can be injected for the examination. If a person is sensitive he will show a spreading, red wheal around the test site. This site is usually the anterior surface of the forearm. Some media are injected into the system. For example, Cholografin or Hypaque; you inject about 0.5 to 1 ml. of the media intravenously and wait at least 10 minutes for a reaction. Your doctor will be responsible for the injection of media.

Some doctors may require you to perform the sensitivity tests after you gain a little experience and others will assume the entire procedure, BUT IT WILL ALWAYS BE UNDER THE SUPERVISION OF YOUR DOCTOR. You will find that there are times when a patient is suffering from certain diseases that will not allow him to be injected with these contrast media. However, it is your doctor who will decide who can tolerate the injections. You will NEVER question him. Showing any surprise or disbelief while in the examining room with your patient will be a serious breach of medical ethics. Your patient could easily lose confidence in the doctor and develop fear or anxiety which would be bad for his recovery. Just keep in mind that a little knowledge can be dangerous and that you are a technician and not a physician!

You are ready, now, to proceed with the various special procedures. You know what the fluoroscopic apparatus is; you are familiar with some of the contrast media by name, what forms you will see them in, some of the types of reactions you may see, and the need for medical ethics. Your first procedure is the gall bladder.

## THE GALL BLADDER SERIES

Radiography of the gall bladder is one of the most frequent examinations done in the Air Force. You will encounter a number of different methods and procedures for these examinations.

### ANATOMY OF THE BILIARY TRACT

The biliary system is made up of the liver, the bile ducts and the gall bladder. The bile ducts come from lobules in the liver. These lobules make the bile and pass it through a system of tiny capillaries. These capillaries keep uniting until they become two large ducts. One duct comes from each lobe of the liver. These two large ducts unite into one duct. This is the hepatic duct. The hepatic duct is joined by the cystic duct of the gall bladder and the duct then becomes the common bile duct. Just before the common bile duct reaches its end it is joined by the pancreatic duct. The common bile duct empties into the duodenum of the small intestine. The opening of the bile duct into the duodenum is controlled by the sphincter of Oddi.

Bile is used in the process of digestion to emulsify fats. Although bile is manufactured in the liver, it is stored in the gall bladder. The gall bladder concentrates the bile by absorbing water from it. When there is no digestive process taking place, the bile is sent to the gall bladder. The bile is released when the digestive process begins.

The gall bladder is a small pear-shaped bag about three inches long and one inch wide. It has a fundus, which is the wide sac part, and a narrow neck. The narrow neck extends until it becomes the cystic duct. On examination the gall bladder may show a variety of different shapes.

The gall bladder is located under the right lobe of the liver. It is oblique and forward in position. Because of this it will appear foreshortened on some examinations. The location of the gall bladder will vary depending on the type of body habitus. In the sthenic (average) person it will be found just below the rib margin in the prone position. In the hypersthenic person it will be found above the rib margin. The hyposthenic person will show it to be a little lower than the sthenic. With the asthenic (very tall and slender person) it may reach into the abdomen below or just above the iliac crest and nearer to the spine.

In all persons the gall bladder will be lower in the erect position than in a recumbent position. And remember that it is always on the right hand side of the body!

## NAMES OF THE EXAMINATIONS

You will encounter a number of different names for the examination of the gall bladder.

| | |
|---|---|
| GB SERIES | This denotes an examination of the gall bladder, either oral or intravenous methods. |
| CHOLECYSTOGRAPHY | "Chole" refers to bile; "cysto" refers to sac; "graphy" refers to picture of. Thus you have a picture of the bile sac. |
| CHOLEDOCHOGRAPHY | Examination of the common bile duct. |
| CHOLANGIOGRAPHY | Examination of gall bladder and bile ducts. Usually this will mean that the injection method is used. |
| GRAHAM-COLE TEST | Examination of the gall bladder. Names of men who developed a gall bladder examination. |

## REASONS FOR EXAMINATION OF THE GALL BLADDER

The examination of the gall bladder is done primarily to test its function. Because the bile is used to emulsify fats during the digestion process, the sac will contract so it can expel the stored bile. When there is pain after eating a meal which contains fat or the physician finds something that indicates poor fat digestion, the gall bladder is examined. There are many reasons why the bile is not being discharged or for malfunction of the gall bladder, such as gall stones, or biliary fistulas, gas, etc. The gall stones are a common cause of malfunction. These stones block the passage of the bile through the ducts. They may be calcified, in which case they can sometimes be seen with contrast media or they can be formed from material which will require media to show them. The pain which is felt is the contraction of the gall bladder in an attempt to eject the bile through the ducts.

## GALL BLADDER CONTRAST MEDIA

The procedure that is used in the examination of the patient will depend upon what type of contrast medium is to be used. Each clinic will use the medium preferred by the radiologist or doctor. In some conditions there may be advantages of using one type of media over another. In the Air Force, the medium is usually given orally in tablet form. However, there are still instances when you may use media that are given intravenously or injected directly into the biliary tract.

PRIODAX. Priodax (Iodoalphionic Acid) is a medium that contains 51.38% iodine. It is used to visualize the gall bladder and is given orally. The medium comes in packages of six tablets with 1, 5, 25, or 100 packages to a box. Six tablets will make one dose. Each tablet is 0.5 gm. Your doctor will tell you how many to give a patient in various circumstances. It concentrates in the gall bladder in about 12 to 15 hours after it is taken. When it is discharged with the bile into the intestine, it is absorbed into the blood stream and is excreted through the kidneys.

A dose of six tablets is given to the patient the night before the examination. He swallows the tablets whole, with sips of water, at intervals of five minutes. Before he takes the pills he should have had a fat-free meal such as cooked or raw fruit, vegetables cooked in salt water, toast and jelly, clear broth, etc. No cream, milk, eggs or fatty meats should be eaten. After the fat-free meal and taking the tablets, he will not be allowed to eat before the examination. He should be warned not to chew the tablets because they have a bitter taste and he might experience a burning sensation. The burning will pass away. Priodax may cause the patient to feel nauseated or produce a diarrhea. If your doctor uses it he will sometimes prescribe some paregoric to be taken. The paregoric will help in the absorption of the medium in the intestine and slow the diarrhea process.

TELEPAQUE. Telepaque (Iodopanoic Acid) is an oral contrast medium which is replacing Priodax in some clinics. It contains 66.68% iodine and has a heavier atomic weight than Priodax. The medium will provide a much denser concentration in the gall bladder. It comes in packages of 6 tablets, which is usually the amount used for an adult dose. The packages come with 5 and 25 in a box. Each tablet is 0.5 gm. Some doctors will only use four tablets while others will use six.

Telepaque will begin to concentrate in the gall bladder about four hours after it is taken. The maximum concentration is usually reached within 10 to 12 hours. Although Telepaque will provide a denser concentration in the gall bladder, faster emptying of the gallbladder is obtained with it than with the other media. This helps in completing the examinations faster. Some patients will experience nausea and diarrhea from it, but the reactions are not as objectional as some other media. Telepaque is sometimes seen unabsorbed in the colon and this might obscure a portion of the gall bladder. Also, because of its denser concentration it might obscure stones that would be seen with other media.

The medium is given 10 to 12 hours before the examination. This will usually be the night before the examination. The patient will eat a fat-free meal. After the meal he will take six tablets and swallow each one separately with water. For patients under 150 pounds, four tablets may be enough. He should not eat anything after he has taken the pills. He may have some fruit juice, black coffee or tea, or water for breakfast. The incidence of nausea or diarrhea with this medium is low, so paregoric is not a normal item in the procedure.

TERIDAX. Teridax (Triiodoethionic Acid) is one of the newer oral contrast media being used in the Air Force for cholecystography. It is supplied in bottles of 30, 100 or 500 tablets. Each tablet is 0.75 gm. It contains 66.5% iodine, so has nearly as much as Telepaque. It has the advantage of being excreted through the kidneys so will not be seen in the colon as Telepaque is. The side effects of Teridax are seen in headaches, epigastric burning, gas or abdominal cramps. These usually pass soon.

Teridax is given in doses according to weight.

| | | |
|---|---|---|
| 150 to 175 lbs. | - | 4 to 5 tablets |
| 175 to 200 lbs. | - | 5 to 6 tablets |
| 200 or over | - | Not to exceed 8 tablets in one dose. |

The medium is given the night before the examination. The patient will eat a

fat-free meal, take the pills, and not eat until the films are taken the next morning. The medium will be concentrated in 12 to 15 hours.

In using any of these three contrast media you have seen that they usually concentrate within 10 to 15 hours after they are taken. You also see that they are given after a fat-free meal the night before the examination. Side effects of nausea, diarrhea, epigastric burning, etc. are present in one or the other. One has the characteristic of denser concentration which is useful in some cases. The others can be excreted by kidneys which lessens the possibility of the medium obscuring the region. So you see that your doctor has to weigh the advantages of one over the other for the specific purpose he has in mind. You should also see that the examinations should be scheduled in the mornings.

CHOLOGRAFIN. Cholografin (Sodium Iodipamide) is a contrast medium that is used for intravenous injection. This contrast medium is used to visualize the gall bladder and biliary ducts, and the procedure itself is known as cholangiography. Cholografin is a relatively new contrast medium. It permits the examination of patients who have nonfunctioning gall bladders. It is also used for those patients who have had the gall bladder removed but still must have the biliary ducts demonstrated.

It comes in 20 cc. ampules with two ampules to the box. Along with the large ampules there are two 1 cc. ampules used to test the patient for sensitivity. The solution is 20%, the usual dose is 40 cc. The patient is tested by injection of 2 minims subcutaneously and, if there is no reaction after 10 to 20 minutes, the injection is given. The injection is given over a period of at least 8 minutes. One half of the solution is given and then the doctor will wait two minutes before giving the other half. The patient may feel a transient feeling of nausea or flushing. This can be helped by having the patient breathe deeply, or the doctor can slow down the rate of the injection.

Other contrast media such as Diodrast and Skiodan Sodium are used in direct injection into the bile ducts. These are usually used in the operating room, or after an operation a tube is left in the ducts and the media injected through it. You also may see the use of sodium tetraiodophenolphtalein, which is an older medium and not so extensively used in the Air Force.

Now that you know some of the contrast media that you will be using to examine the gall bladder, you will learn what procedures are taken to perform the radiographic part of your job. This is where your work begins.

## GALL BLADDER EXAMINATION

Just what do you as a technician have to do? You will have to prepare the patient for examination, position the patient, identify each exposure and set your techniques. Procedures will vary from clinic to clinic. Some will require films at a certain period of time, etc. You will ALWAYS be learning some variation of the basic procedure.

### PREPARATION OF THE PATIENT

Gall bladder examinations are scheduled in the mornings in most clinics. The

patient will come to the clinic with a request for the examination. He is given the proper amount of contrast media and the proper instructions. These instructions should be written or mimeographed so that they cannot be forgotten by the patient. He must understand and follow them explicitly.

## SAMPLE INSTRUCTIONS

1. You are preparing for an examination of the gall bladder. The pills that you have been given are known as _________. These pills will cause your gall bladder to be seen on an X-ray film. They concentrate in the bile of your gall bladder about 10 to 15 hours after you take them.

2. When you go home tonight do not eat anything with fat in it. You can eat raw or cooked fruits, vegetables boiled in salt water, toast and jelly, black coffee or tea. Do not eat eggs, cream, milk, butter or anything with fat in it. If you do the gall bladder will spill out all the dye you have taken and the examination will have to be repeated.

3. Take the pills that you have been given and swallow them five minutes apart with sips of water. DO NOT CHEW. DO NOT EAT AFTER YOU TAKE THE PILLS. You may have water, but don't eat until the doctor tells you that you can eat. Take the pills at ___________.

4. Take a cleansing enema at ___________. This will remove any gas or feces in the colon which might cover up your gall bladder and make another examination necessary.

5. You may experience a feeling of nausea or diarrhea, or slight burning, but these are natural and will pass. However, if you vomit the pills, let the technician know. The dye will not be in your gall bladder and the examination will not be good.

6. You will report to the X-ray clinic at ___________ o'clock on _________. You will be there for at least ________ hours.

7. If you have any questions on how to prepare for this examination call 01001 . The success of your examination will rest a great deal on your following these directions.

## PRELIMINARY FILMS

Preliminary films are taken before the regular series of films are made. These films are taken with 10 x 12 cassettes with no attempt to cone down on the gall bladder. These films will show the location, amount of contrast medium that has concentrated, and any gas or feces that may be covering the region. Sometimes these preliminary films are taken before the patient takes the contrast medium. These will reveal the presence of gall stones that have calcification around them and the administration of the medium may not be necessary.

## RADIOGRAPHIC POSITIONS

Radiographic positions used to show the gall bladder will vary from clinic to clinic. The usual positions are the posterior-anterior, the posterior-anterior oblique and the upright. The anterior-posterior, lateral and right lateral decubitus are also used. The posterior-anterior is used for the preliminary films.

POSTERIOR-ANTERIOR VIEW. Use an 8 x 10 cassette placed lengthwise in the bucky tray. The patient is placed in the prone position. The right side of the body is centered to the center of the white line on the table. The film is centered to the location of the gall bladder. (This location is found by marking the body with a skin pencil where you centered the preliminary film). The left arm is extended alongside the body and the head is resting on the right arm. The central ray is directed perpendicularly to the center of the film. The patient will suspend respiration on full inhalation. A cone is used for a 6" cone field. Measure through the central ray. ID is burned in at the top of the film. Make sure that you have the proper markers on the film.

POSTERIOR-ANTERIOR OBLIQUE VIEW. Use an 8 x 10 cassette placed lengthwise in the bucky tray. Use cone. The patient is prone on the table. The amount of obliquity will be determined by the location of the gall bladder. Usually the body is obliqued 30 degrees and again at 60 degrees. The thinner your patient the greater obliquity you will need. The central ray is directed perpendicular to the center of the film. Film centered to the position of the gall bladder. Suspend respiration after full inhalation. Measure CR. ID is burnt in at the top of the film.

LATERAL VIEW. Use an 8 x 10 cassette placed lengthwise in the bucky tray. Use a cone. Place the patient in a right lateral position. Flex the knees and place the arms about the head. Center the body so the spine is just posterior to the center line on the table. Center the film to the location of the gall bladder. Direct your central ray perpendicular to the center of the film. Measure your central ray. Burn your ID in at the top. Take the film while the patient suspends his breath after full inhalation. (This position is used to bring the gall bladder away from the spine in thin patients and also to show any irregularity in the shape of the organ).

UPRIGHT PROJECTION. Use an 8 x 10 cassette placed lengthwise in a vertical cassette holder. Use a cone. Place the patient in the standing erect position. Center the marked gall bladder to the center of the film. (Keep in mind that the gall bladder will drop down, back and toward the midline of the body in this position). Direct your central ray horizontally to the center of your film. Take the exposure on full inhalation. Measure your central ray. ID burnt in at top of film. (This view is used to show how far the gall bladder moves, float unseen stones or show those that are heavier than the bile. Also it will show whether tumors are present).

ANTERIOR-POSTERIOR VIEW. This position is a reverse of the PA and is used at times during direct injection of contrast medium in cholangiography. Tube is under the patient and film is placed over the patient. The same routine centering, etc. are used as in the PA.

## FATTY MEAL

A FATTY MEAL is given to the patient after the first series of X-rays have

been taken. As you know the bile helps to emulsify fats. These fats have been avoided before the examination so the media would be able to concentrate in the bile. Because part of the reason for taking an examination of the gall bladder is to see how it functions, you must give the patient something to eat which will cause the gall bladder to eject bile. This is done by giving the patient a meal that contains fat. This can be regular food such as eggs, bacon, cream in coffee, butter and toast, etc., or you will find that certain commercial meals are available in the Air Force. These preparations are known by trade names such as Cholex, Cholestin, Neo-Cholex and Bilexac. These contain fatty elements which allow you to perform your examination faster. Without them your patient would go to the hospital mess or a cafeteria for the fatty meal.

After a fatty meal has been taken the gall bladder is X-rayed again to see how it is emptying. The time of this emptying will depend upon the type of meal given. Usually the film is taken one hour after the meal, but with some commercial meals this can be done within forty minutes. Then, too, your doctor may want to have films taken at specific periods of time such as 15 minute intervals after taking the fatty meal. The position used will usually be the posterior-anterior. The doctor may want other positions and these will probably be posted as part of your routine for the examination.

## BEHIND AND AHEAD

So now you have an idea how to examine the gall bladder. Review the procedure.

- Schedule patient for examination.
- Provide patient with instruction sheet and media.
- Take preliminary films without coning field on 10 x 12 cassettes. Sometimes these are done before medium is given. Check position, filling and freedom of field.
- Perform the exposures; PA, Lateral, PA Oblique, Upright, Right lateral decubitus or AP positions. Do only those positions used by your clinic or ordered by your doctor.
- Give a fatty meal.
- Take your post-fatty meal films as ordered by the doctor or those listed as routine in your clinic.

You should now know what Priodax, Telepaque, Teridax, Cholografin are, how they are used, what reactions you might expect from them and what they do. You know some of the names used to identify examinations of the gall bladder, how to prepare the patient for the examination, what positions are used and what a fatty meal performs in the examination.

The next section will tell you about the procedures used for examining the urinary system. Examinations of the urinary system are done very frequently in the Air Force.

# THE URINARY SYSTEM

The urinary system is examined to show the entire system, various conditions or parts of the system. Special procedures for the visualization of the parts of this system are varied. In some examinations the actual function of the system is studied, and in others the outline of the various organs forms the basis for the examinations.

## ANATOMY OF THE URINARY SYSTEM

The X-ray technician is primarily interested in where the various organs of the system are located and what they look like in their normal condition. He is also interested in changes in the appearance of the organs made by the shifting of positions and the filling of the organs with medium.

The urinary system consists of two kidneys, two ureters, a bladder and a urethra.

The kidneys are bean-shaped. They are about four inches long and two and a half to three inches wide. The left kidney may be a little longer than the right. They sit in the posterior wall of the abdomen with the upper third in front of the twelfth rib. The upper half of the right kidney is behind the liver. Anteriorly, the kidney can be found on the transpyloric plane. Posteriorly, their centers are found on the level of the first lumbar spinous process. When the patient stands the kidneys will drop down about one inch from the position they assume in the supine position.

The ureters begin in the hilum of the kidney. The funnel-shaped part of the ureter, at the upper end, is called the renal pelvis. Above this pelvis are the calyces of the ureters. The ureters extend down 10 to 12 inches and enter into the lateral wall of the bladder. The ureters enter the bladder about 1-1/2 inches above and lateral to the symphysis pubis. As the ureters come down from the kidneys they pass in front of the psoas muscle and the sacro-iliac joint. The ureters will exhibit peristaltic motion that brings the urine down to the bladder.

The bladder is a musculomembraneous sac that holds the urine. In adults, it is located mostly above the symphysis pubis, but part of it will lie below it. In infants and small children you will find it located above the symphysis pubis. When the bladder of the adult is full it can extend 3 inches above the symphysis pubis.

## NAMES OF EXAMINATIONS

The names of the various examinations of the urinary system will tell you what type of procedure is to be followed.

| | |
|---|---|
| Urography | This refers to the overall examination of the urinary system and does not differentiate between types or areas of examination. |
| Nephography | This term is not often seen or used. It has the same meaning as urography. |

| | |
|---|---|
| Intravenous Pyelography (IVP) | This is an examination of the function of the urinary system. It is performed by injection of the contrast medium into a vein. |
| Retrograde Pyelography | This procedure is the injection of the contrast medium through a cystoscope or catheter to outline the various organs of the system. |
| Cystography | This is the injection, by catheter or cystoscope of medium into the bladder. |
| Urethrography | This is the outlining of the urethra with contrast medium. |

## REASONS FOR EXAMINING THE URINARY SYSTEM

As has been said, the urinary system is visualized to diagnose a number of conditions. The urinary system is radiographed to show urinary calculi in the kidneys, ureters, and bladder. These are the familiar kidney stones. Sometimes these can be seen and other times the "stone" is of material which cannot be seen on a radiograph. The kidneys are examined for dilation of renal pelves, ureteral constrictions or kinking, tumors and anomalies. The bladder can show foreign bodies and "stones", either developed in the bladder, or brought down from the kidneys or ureters. It is also examined for diverticula (which are pouchlike projections from the wall), tumors, and congenital defects. The prostate gland and the urethra are also examined for calculi. Probably calculi will be the most common cause for examination of the tract. Because some of the conditions that can affect these organs also can affect your procedures, you will be modifying your techniques a great deal as to position and number of film. There are many confusing shadows that can occur in this area and sometimes it will take more than the normal routine demonstrations to get an accurate diagnosis.

## CONTRAST MEDIA USED FOR URINARY SYSTEM

There are a number of contrast media that are used to visualize the urinary system. Most of these will require a sensitivity tests, as they contain iodine. Again, the preference of the doctor or the purpose of the examination will determine just which media will be used in your clinic. Some of these media have been used for some time in the Air Force and others are new developments which offer certain advantages, such as increased density or reduced reactions.

UROKON SODIUM. Urokon sodium (Sodium acetrizoate) is a medium used for both intravenous pyelography and the retrograde pyelography. It comes in solutions of 30% and 70% concentration. It is a sterile aqueous solution supplied in ampules or bottles. Each ampule or bottle contains 25 cc. of the solution. The iodine content is 65.8%. The medium is rapidly excreted unchanged in the urine.

The usual adult dose is 25 cc. of the 30% solution for intravenous pyelography. It is injected over a period of 2 to 5 minutes. X-rays are usually taken at 5, 10, 15

and 30 minute intervals after the injection is completed. In children, the doses will be smaller and the doctor will tell you how much will be needed.

This medium will cause various type reactions in some people. These reactions can be a feeling of nausea, vomiting, pain in the arm at the site of injection, flushing, urticaria, or a strange taste in the mouth. These reactions are usually short in duration. The patient should be informed of these possible reactions so that he will not have fear of them during the procedure. The patient can be relieved of some of the symptoms if he breathes deeply and relaxes himself as much as possible. A sensitivity test should be taken before the medium is injected.

Depending upon the degree of contrast desired, a full 30% solution is given in the retrograde examination. Or it can be diluted as requested by the doctor.

DIODRAST. Diodrast (Iodopyracet Injection) is a colorless, aqueous solution with approximately 50% iodine content. It is also used for both intravenous and retrograde pyelography.

In the intravenous examination, 20 cc. to 30 cc. of a 35% solution is used in adults. For children, the dosage is given according to age or as your doctor orders; 5 cc. under 6 months, 6 to 10 cc. for those 7 months to 3 years and 10 to 20 cc. for those who are 4 to 8 years old. Diodrast may also be given intramuscularly to those people who have inaccessible veins. It is given in the buttocks; half of the total injection in each one. Adults will receive from 20 to 30 cc. and children 10 to 20 cc. The medium may also be injected subcutaneously if it has been diluted about four times.

When the retrograde examination is done, 20 cc. of a 15% to 20% dilution of the solution is given.

Diodrast may cause a feeling of warmth, flushing, nausea, vomiting, cyanosis, eruptions of the skin, or dyspnea. Each box of Diodrast contains a sensitivity ampule with each of the larger injection ampules.

Diodrast comes in 35%, 50% and 70% solutions. Diodrast in 35% strength is packaged in boxes of 1 to 25 ampules with 10 cc., 20 cc., or 30 cc. in each ampule.

SKIODAN SODIUM. Skiodan sodium (Methiodal sodium) contains 52% iodine. It can produce dense shadows and is excreted in the urine without change. It is usually non-irritating when injected directly into the urinary tract.

For intravenous pyelography a 40% solution of 50 cc. is given to adults. The doctor will determine the amount to be given to children according to their age. Retrograde examinations will use a solution of 15% to 20% and cystograms from 3% to 5%.

Skiodan will present the same type of media reactions as the others already mentioned.

NEO-IOPAX. Neo-iopax (Sodium iodomenthanate) is a clear, colorless solution containing 51.5% iodine. It is used for both intravenous and retrograde pyelograms. It is used to test the function of the excretional capacity of the kidneys.

Adults are injected with 20 cc. of the 50% solution and children with 10 cc. For

retrograde pyelograms the solution is diluted to 20% concentration with sterile, distilled water. If the examination is to show both sides 25 cc. is used and only 15 cc. is used to show one side.

Neo-Iopax comes in solutions of 50% and 75%. The 50% has 10, 20, or 30 cc. ampules in boxes of 5 and 20 ampules.

Observation for reactions similar to the other media should be kept.

Other contrast media coming into use for the examination of the urinary system are Hypaque, Renografin and Miokon. These are used for other types of examinations as well as for urography, but the principle of use is about the same. The main search of the new contrast media is to find those which will offer less reactions. These new contrast media do offer some improvement.

## EXAMINATIONS OF THE URINARY SYSTEM

The technician has a number of duties to perform in preparing the patient for the examination, and sometimes is required to do more unusual positions. In larger hospitals, the examinations are performed by the urologist. He has a special piece of equipment which is a combination of a urology table and an X-ray machine. Radiologists, of course, do a great many of the examinations, but you should know that you may work in both areas. The examinations are termed excretory when the intravenous method is used. This is performed more commonly than the retrograde. It is used to test function as well as to outline various conditions. The retrograde type of examination is known as the instrumental method because a cystoscope and catheter are introduced through the urethra into the bladder. The medium is then injected through the instruments into the organs. This method is used to outline the organs into which the medium is injected. Also this method provides a denser concentration in these organs than is obtained in the intravenous method. However, the use of instruments is disagreeable and sometimes cannot be used when certain conditions exist, so the intravenous method is usually easier to perform.

PREPARATION OF THE PATIENT. It is essential that the alimentary tract be free of gas and feces so that it doesn't cover the area to be examined. Generally the patient will take a cleansing enema at least 1 to 2-1/2 hours before the examination. Some time before the examination the patient may be placed on a low residue diet. Laxatives can also be given, but all of these preparations will be ordered by the doctor. If there is a great deal of gas a preparation known as Pitressin may be injected. From 0.5 to 1 cc. of this solution is injected intramuscularly about 1 hour before the examination is to begin. It helps to eliminate the gas. Also gas is removed by inserting a flatus tube into the rectum. And, of course, in some clinics patients are examined without any type of preparation. However, a basic preparation procedure is usually followed in the Air Force as described below.

- Patient is scheduled for examination in the morning.
- He is instructed to take a laxative the night before the examination and a cleansing enema.
- He is told to restrict fluids and food until he has his examination. A fluid restriction is necessary in the intravenous method to provide con-

centration of the medium in the urine. Normal fluids will dilute the medium and the contrast may not be great enough to reveal the system.

- He will take a clear water enema about 2 hours before examination.

PREPARATION OF EQUIPMENT. The technician prepares the medium, injection equipment, and obtains compression equipment to be used during the examination. He also prepares the patient for a sensitivity test. This test may be given by the technician, radiologist, or done in the allergy clinic. The skin test, injection test, or the eye test can be used for sensitivity. The skin test is the intradermal injection of a small amount of medium into the skin of the forearm. It is watched and if there is not a reaction in 5 to 10 minutes the injection is given. The intravenous injection method is the injection of a small quantity of the solution into the vein. If there is no reaction in 10 to 15 minutes, the injection can be made. The eye test is simply placing a drop of the solution in the corner of the eye. If the eye becomes inflamed or red the patient is sensitive.

In any event, even after sensitivity tests have been given, some type of drug is available during the examination in case of sudden reactions or increase in severity of normal reactions. In the Air Force the usual drug is adrenalin. Two cc. of the drug is placed in a syringe and kept near the patient. Other drugs used to combat media reactions are Bendryl, levarterenol, and amobarbital sodium. Your doctor will tell you which will be prepared. You should have a basin available in case the patient becomes nauseated.

Now that you have a general idea of what you are going to do, you will study each method that you will probably have to perform.

## INTRAVENOUS PYELOGRAPHY

The patient is dressed in a cotton gown. The radiographic table is prepared by placing the shoulder rests on the table and also the foot board is attached. The injection tray is prepared with the contrast medium, needles and syringes, adrenalin syringe, tourniquet, sensitivity test equipment, alcohol sponges and basin. The sensitivity test is given and patient watched for reactions.

The patient is positioned on the table in the anterior-posterior position. He is informed of the normal reactions he may experience. The technician will place the compression apparatus into position. This compression device is a restraining band on the table with a rubber, air-filled bladder or a non-opaque towel or pad under it. Care must be taken to see that there are no folds in the patient's gown or in the band that will cast shadows on the film. The compression pad is placed on the abdomen above the symphysis pubis and the restraining band is tightened as much as the patient can bear. This device will prevent the medium from escaping into the bladder and help concentrate the dye in the kidneys and ureters. Some doctors will prefer that the table be tilted in the Trendelenburg position so that natural gravity will slow the medium's flow to the bladder.

Prior to the application of the compression device a preliminary film is taken to investigate the cleanliness of the area. This film will sometimes show a condition without the medium so the examination may not have to be performed. The film will be positioned so that it will include the entire urinary system. Thus the lower border

of your film should be at the level of the symphysis pubis.

After the doctor looks at the preliminary film he is ready to begin the procedure. You will place the tourniquet around the patient's arm. THE DOCTOR WILL INJECT THE MEDIUM into the antecubital vein. This injection process will take from 2 to 5 minutes depending on the medium.

Using 14 x 17 cassettes and keeping the patient in the AP position, you will take films at 5 minutes, 10 minutes and 15 minutes after the end of the injection. Each time they should be taken at the end of inhalation. Keep the patient on the table with the compression in place and at the end of another 15 minutes take a film in the upright position. This position will show the bladder filled with the medium. Each film should have a time and position marker on it so it can be identified.

## A SHORT REVIEW OF IVP

- Patient is scheduled for morning examination.
- Patient instructed to abstain from fluids and food from supper until after the examination. He is also instructed to take a laxative or enema if ordered.
- Patient reports to clinic at appointed time.
- Technician prepares injection equipment and radiographic room.
- Patient is dressed in cotton gown and placed in the anterior-posterior position on the table. Compression applied, if required.
- Preliminary films taken and read.
- Sensitivity test is prepared and given. Watch for reactions.
- Contrast medium is prepared; tourniquet applied; doctor injects medium from 2 to 5 minutes.
- Films are taken 5, 10 and 15 minutes after injection. The upright film is the 30 minute film with the compression device removed. Films may be read in between and additional exposure and positions used to complete the examination.

After the examination is over the contrast medium is eliminated in the urine.

## RETROGRADE PYELOGRAPHY

The patient will be examined in the urology clinic or in a room reserved in the radiographic department for this procedure. Usually a G. U. technician is available for the procedure, but you may be involved. Each doctor will use the type of equipment he prefers and this varies from clinic to clinic. A sterile technique is used in this type of examination. The equipment will include a cystoscope which is introduced into the bladder. A catheter is inserted into the cystoscope and directed into the

ureters. The contrast medium is injected through the catheter. About 5 cc. to 20 cc. is used. The injection is made until the patient complains of slight discomfort in the back. This will indicate that the first exposure is now ready to be made. The doctor will hold the pressure on the medium until the exposure is made. This prevents the medium from dropping down out of the pelvis before the exposure can be made. This filling of the ureters and the kidneys may be followed under the fluoroscope also.

You will normally find the patient in the anterior-posterior position, and this position is the one used to take the radiographs. However, the doctor may direct other views such as an oblique or a tube angulation. You, as an X-ray technician, will generally be required to take the radiographs only. The patient preparation and the injection of medium, etc. will be done by the doctor and the G. U. technician.

If you do help in the preparation of the patient you must prepare the patient for the doctor. He will perform the actual visual inspection, insertion of the cystoscope and the catheter and inject the solution into the organs.

HOW DO YOU PREPARE FOR RETROGRADE PYELOGRAPHY? The patient is encouraged to take as much fluid as he can, instead of restricting fluid as in the intravenous method. This procedure is required because the doctor will sometimes collect specimens from the kidneys as well as outline the system. Your patient should be assured that the procedure will only cause mild discomfort. Some patients have a definite fear of work being done within their bodies while they are conscious. The patient is then scrubbed around the genital area with a preparation known as PhisoHex and water to create a sterile area. A perineal towel with a 3 x 3 hole in it is placed over the genitals and the draping completed with a perineal sheet.

Retrograde pyelography is usually done under local anesthesia. The anesthesia used can be Metycaine 4% or a 2% solution of Aqueous Xylocaine. The female urethra is more sensitive at the meatus so a cotton tip is used to place the anesthesia on it to deaden the feeling. In the male an Asepto syringe equipped with an acorn tip is used. The anesthesia is injected into the urethra and a clamp is placed about the penis to hold the drug in for a few minutes.

PROCEDURES OF EXAMINATION. While the sterile field is maintained the doctor will introduce the cystoscope into the urethra and bladder. Through the cystoscope he will insert catheters into the ureters and inject the amount of contrast medium that he desires. Prior to the use of the cystoscope and contrast medium he may have made another type of test of kidney function. This is the injection of phenolsulfonphthalein into the vein. This solution then circulates through the system into the kidneys where it will reveal the functional ability of the kidneys. When the doctor inserts the cystoscope and catheters he may take a sample of the urine in the kidney pelvis. The amount of this solution that appears in the sample after a period of time helps to determine the ability of the kidney to function adequately. The injection of the contrast medium and the phenolsulfonphthalein test are sometimes done together in one examination.

The number of films and amount of time between films will be determined by the doctor. He may want one after full injection as has been stated and then others periodically. He may want obliques, AP's or sometimes stereoscopic views. There is no prescribed manner of procedure so you must be alert to all situations so that you won't need to repeat your films.

You now have knowledge of the retrograde procedure. One word of caution must be made in regard to handling the equipment. The cystoscope is a very delicate instrument and costly. Whenever you are required to handle it be sure that you don't scratch it or drop it. It is made so that the surface is extremely smooth. A rough scratch on the instrument can cause injury as it is inserted through the lining of the urethra.

## CYSTOGRAPHY

Cystography is the examination of the bladder with contrast medium. In the preparation for this examination your patient will take laxative and cleansing enema 12 hours before the examination is scheduled. These examinations are scheduled in the morning as are the others. The patient is told to restrict solids and fluids from supper the night before until after the examination. This is to prevent excess urine from forming and to keep the bowels free from material. Another clear water enema is given 1 to 3 hours before the examination.

The patient will report to the examination room and be prepared as was done in the retrograde procedure. The doctor will insert the largest cystoscope that the urethra can take into the bladder. The doctor selects the medium and the solution is injected so that there is enough to distend the bladder. As may be expected, he must clamp off the catheters so that there will not be an outflow of the solution.

A 10 x 12 lengthwise film is placed in the bucky tray. The tube is centered as in the AP pelvis, and then angled 10 to 15 degrees toward the feet. Center your film to coincide with the central ray. The doctor may want AP's, PA's, obliques, or stereo views, so there is no specific routine position in these examinations either. The first film is taken with the bladder full. Any second or subsequent film will be up to the doctor conducting the examination.

Air is sometimes used instead of a solution as a contrast medium. Air will show up certain conditions that a contrast solution may cover up. This is then known as pneumocystography.

## URETHROGRAPHY

Urethrography is the visualization of the urethra. The medium may be air or a contrast solution. The contrast solution may be mixed with acacia, which is a substance that causes the medium to cling to the sides of the urethra. This mixture will allow the medium to outline the urethral passage. The urethral meatus is clamped to prevent the outflow of the medium after it has been injected by the doctor.

Usually a lower penetration technique is required for the penis portion of the urethra. The oblique position is used to demonstrate the deep or posterior urethra.

## BEHIND AND AHEAD

You should now know what an intravenous pyelogram, retrograde pyelogram,

cystogram and urethrogram are, how you prepare your patient for them, what your duties are, what equipment is prepared, who performs the injections, and the positions you will be required to use in the examinations. As you have seen there is a definite need for teamwork between the doctor and the technician. Each procedure should be learned the way your doctor prefers them. If you have any doubts or confusion on any technique that is to be used, ASK YOUR DOCTOR BEFORE YOU BEGIN. It is imperative that a technician is accurate in his duties. It is better to ask questions than spoil an important examination.

In the next section you will learn the procedures used in examination of the digestive system with barium sulfate solutions. You will learn how to do esophagrams, GI series and barium enemas. These examinations will be almost routine in a number of Air Force clinics. In these procedures you will see fluoroscopy, spot-filming and routine radiographic work combined.

## THE DIGESTIVE SYSTEM

The examination of the digestive system with fluoroscopy and radiographic techniques is the next most common procedure performed in X-ray. Most of these examinations are performed on individuals over thirty years of age, but they can be done on younger persons. There are a variety of conditions that will cause your doctor to examine the organs of the tract. You will learn a few of these, how to prepare your patient for the examinations, what medium you will use, how to set up your room for the examinations, etc.

### ANATOMY OF THE DIGESTIVE SYSTEM

Review the basic anatomy of this system in Chapter IV. As you know, the system is made up of the mouth, pharnyx, esophagus, stomach, duodenum, jejunum, ileum, ascending colon, transverse colon, descending colon, sigmoid, rectum and anus. The system is one hollow tube with dilations along its various points for specific functions, and a change in diameters in various places.

An important fact to be considered is the time that it takes to empty the various segments of the digestive tract. When you are using a contrast medium it will be up to your doctor to determine what is normal time for passage through each section. You will find a variety of times offered for the passage of material through each section of the system.

Generally there will be more peristalic action in the upper sections of the system than in the lower. This is important to remember when you are setting time for your techniques. It will take from 0.1 to 0.3 seconds for food to pass through the esophagus to the stomach. Of course, this will depend on the type of food swallowed-liquid or solid. Because the stomach is churning when some material is present in it, motion is produced during exposures. The exposure should be as fast as possible. The duodenum will show more peristalsis, but as the intestines extend peristaltic action will become more sluggish.

## NAMES OF THE EXAMINATIONS

The various names that are given to the examinations of the digestive system will generally refer to the area to be examined.

| | |
|---|---|
| Esophogram | This is a radiograph of the esophagus. |
| Barium Swallow | This is a procedure to demonstrate the esophagus or surrounding organs by taking films while the patient is swallowing a contrast medium. |
| Gastro-Intestinal Series (GI Series) | This procedure is filling the digestive tract with contrast medium by having patient drink a solution and then studying its progress through the system. |
| Barium Enema (BE) | This is the administration of the contrast medium into the large colon using an enema. |
| Double Contrast | This is the use of an enema of an opaque contrast medium and, then, after removing this medium, injection of air into the colon as a second medium. |

## REASONS FOR EXAMINING THE DIGESTIVE SYSTEM

Probably one of the most common reasons for examining the digestive system is to check for ulcers or cancer. Ulcers will occur in the pyloric section of the stomach or along the upper or lesser curvature. These ulcers are the common peptic ulcers. Ulcers also occur in the region of the duodenal cap or the first part of the duodenum. These are duodenal ulcers. This condition is the eating away of the dead tissue which is caused by a number of different things. This material is digested just like a piece of meat is digested. When this digestion of the tissue continues there can be a "perforation" of the wall of the stomach or duodenum. This is what makes the ulcer so dangerous. The hydrochloric acid in your stomach keeps annoying the area near the pylorus or the duodenal cap until a hole is made and the contents spill out into the abdominal cavity. Ulcers do not occur below the duodenal cap frequently, because the bile and pancreatic juices are alkaline and they neutralize the acid which is necessary in eating away the dead tissue of an ulcerated area.

Cancer of the stomach is another disease. This will generally occur in the pyloric end of the stomach. It is also found in the lower end of the esophagus and the sigmoid or rectum portions of the large intestine. However, cancer can be found in other areas of the digestive system.

The motility or amount of motion of the stomach, the filling of the various sections, the emptying times of these parts of the digestive system, or the dilation of various areas are reasons for examination of the digestive tract.

The thing to remember about each examination of the digestive system is that each person will be an individual case. The routine procedure will vary from doctor to doctor and from patient to patient.

## CONTRAST MEDIA FOR THE DIGESTIVE SYSTEM

Barium sulfate is the contrast medium for the digestive system. This medium is a white powder that is mixed in various ratios with water to form paste, thick or thin solutions. The consistency of the medium will depend on the region in which it will be used. The medium has a number of different trade names. Some of these are Basolac Barium, Gastropaque and Baroloid. The barium sulfate comes in canisters of 1 and 5 pounds. These cans should be kept closed when not in use.

## ESOPHAGRAM (Barium Swallow)

This is the examination of the esophagus and is also used to show the displacement of other surrounding organs. If the esophagus is not in the proper position, then there may be a growth or some other condition in the heart, great vessels or lung. However, the procedure is mainly performed for visualization of the esophagus. It will show lodged foreign bodies in the tube, conditions that effect the act of swallowing, cancer of the lower esophagus, etc.

PATIENT PREPARATION. Preparation of the patient is not necessary if the esophagus is the only organ to be examined. If it is a part of the GI series, there will be additional preparation. The patient is allowed to eat and drink as he wants. He will report to the clinic at the scheduled time. He will be undressed and given a cotton gown to wear.

The technician will set the radiographic room up prior to the time of the examination. The table will be placed in the upright position. The machine will be set on the settings required by your doctor for fluoroscopy. You will make up the barium sulfate solution and have it ready for the examination.

There will probably be two mixtures that will be used. One is barium in a paste-like form made from 6 to 8 tablespoons of barium mixed with water. The other will be a thinner liquid made with two parts barium to one part water. A spoon will be necessary to feed the paste to the patient.

You will do the examination with fluoroscopy and, possibly, spot-films. The films should be ready for the doctor. After the fluoroscopy you will use 14 x 17 inch films for radiographic examination.

FLUOROSCOPING. Fluoroscoping will be done by the radiologist. The patient will be in the upright position. The footboard of the table will be in place and the patient will stand on it. The patient is usually in position with his left posterior surface against the table and the right anterior surface next to the screen. The doctor will perform a preliminary screening by running the screen up and down the patient's body. After this is finished, he will request you give the patient the medium. You will take a spoonful of the medium and hand it to the patient. The patient will take the barium paste and hold it in his mouth until the doctor tells him to swallow it. The doctor may also examine the patient swallowing the thinner solution. This may be done several times and the doctor may take some spot-films. You should have cautioned your patient about the taste of the barium paste and the necessity of controlling any gagging reaction. Sometimes the mixture is flavored with chocolate or some other flavoring to make it better tasting. Take a little barium paste yourself so you can see what the patient will feel like.

RADIOGRAPHING. Radiographic films are taken when the fluoroscopy is finished. The films can be done in the upright position or with the patient lying down. The patient takes a deep breath, swallows the barium and then the exposure is made. This action will slow the progress of the barium down the esophagus and allow the tube to become coated. This is rather important because the medium may reach the stomach before the exposure can be made and you will not get as good an outline. Depending upon the thickness of the solution, you will count from one to three after he swallows the barium and then make the exposure. This will give the barium time to coat the esophagus. The time of exposure should be as small as possible.

The usual routine view for the esophagus is a right anterior oblique (RAO). However, you will do left anterior obliques, right posterior obliques or left posterior obliques. The positions used will be determined by your radiologist. You can do these either upright or recumbent. The film is centered to the fifth thoracic vertebra so you will be sure to include all of the esophagus.

A SHORT REVIEW OF THE ESOPHAGRAM

- No preliminary patient preparation necessary.
- Prepare barium sulfate in two mixtures - a paste and a solution.
- Have patient put on cotton gown.
- Position table and set machine for fluoroscopy.
- On request of doctor give patient spoonful of barium paste. The patient will be given the thinner mixture to hold in his left hand. He will drink it on doctor's orders.
- Take radiographs with patient in RAO, LAO, LPO, RPO, as directed by doctor. This can be done in either the erect or recumbent positions.
- Have patient swallow barium after full inhalation and then count before making exposures. Center film to fifth thoracic vertebra.

GASTRO-INTESTINAL SERIES (G. I. SERIES)

This is an examination of the stomach and small intestine with barium sulfate. You will use fluoroscopy, spot-films and radiographic procedures in these examinations. The mixture of the barium will determine, to some extent, the amount of time that it takes to empty the various sections of the tract. Some doctors will want hourly films for five hours. Others will only request a one hour film and then a five hour film after the medium is given. Each examination will be an individual problem and you will receive the proper orders from your doctor as to what he specifically wants you to do.

PATIENT PREPARATION. Preparation of your patients will start by scheduling them for examination in the morning. The patient will be restricted for at least 12 hours from food and drink. The bowels should be free from gas or feces, so an enema should be taken on the night before the examination. Another clear water enema can be taken at least three hours before the examination.

MEDIA PREPARATION. Preparation of barium sulfate solution is done prior to the examination. It will be made with one part barium to one part water. The formula will vary from doctor to doctor. The solution is mixed in an electric mixer if you have one. You must see that the solution is thoroughly mixed before it is given to the patient.

PREPARATION OF EQUIPMENT. You will put the table in the upright position with the foot rest attached to the table. The machine is set for fluoroscopy. The fluoroscopic chair, lead aprons, lead gloves, and dark adaption goggles are made ready for the doctor. Skin pencils are made available. These are red or blue wax pencils used by the doctor to make marks on the patient's skin for positioning purposes. Also compression devices for spreading solution in the stomach are made available. You will keep a spoon or stirrer handy to stir the solution again before it is given to the patient, as the solution settles after standing awhile. The patient is dressed in a cotton gown and the procedures are explained to him so he will understand what he is expected to do. Spot-films are readied and the equipment checked to see that it will operate as expected.

FLUOROSCOPIC EXAMINATION. After the doctor has adapted himself to the darkness he will begin the examination. The patient will be positioned with his back to the table. The doctor will perform the preliminary fluoroscoping. At the request of the doctor, you will give the patient the glass of barium solution to hold in his left hand. You will caution him to hold it at shoulder level so the doctor won't strike his arm with the screen and spill it. The doctor will tell the patient to take a swallow of barium and then will fluoroscope again. After the patient has drunk the solution, the doctor will fluoroscope and make spot-films of the stomach and duodenal cap as he wishes. You will keep him supplied with films as he needs them. He may place the patient into the horizontal position after the upright fluoroscoping and again fluoroscope and take spot-films. He will mark the patient with the skin pencils to help you locate the stomach for later films.

FILMS. Radiographic films are taken after the fluoroscopic examination is completed. Sometimes these films are taken on the same table where the fluoroscopic procedures were performed, but in busy clinics the patient may be sent to another room for these films.

You will take a variety of films on these patients. The two most common positions that are used for routine view of the stomach are the posterior-anterior and the posterior-anterior oblique. You may be required to take two PA's or two PA obliques. The two obliques can be taken with the body rotated 36° and 60°. You may also be called upon to perform anterior-posterior positions and right laterals. These positions may be either erect or recumbent, but most of the time the patient will be recumbent. Each case will be an individual case and films will be made on orders of your doctor.

It must be kept in mind that the stomach will change positions when the patient moves from the recumbent to the erect position. You should center your film accordingly. You will be using 10 x 12 cassettes for the stomach and duodenum and a 14 x 17 cassette for the small bowels. You will probably use a 14 x 17 in some cases for the stomach as well. The main thing to remember is the body habitus and that the position will affect your centering. You will gain proficiency from experience in localizing

these structures. Markers should be placed on these films to tell which position was used.

After the first series of films have been taken, the patient will return for films at one, five and possibly twenty-four hours after eating the barium meal. Some procedures will require a four-hour or a six-hour film. These time films will vary depending upon your doctor and the purpose for which they are taken. Markers should be placed on each film designating the time of the film.

Films for the small intestine or large intestine, taken to follow the meal through the intestines, are taken on 14 x 17 cassettes with the patient in the posterior-anterior position.

A SHORT REVIEW

- Patient scheduled for examination in morning.
- Patient restricted from food and drink for at least 12 hours prior to examination.
- Enema taken night before to remove gas and feces from colon. Clear water enema given at least 3 hours before examination.
- Examination set up for fluoroscopy. Barium sulfate solution mixed with one part barium to one part water. Spot-films ready for use. Fluoroscopic chair, lead aprons, lead gloves and skin pencils ready for use by doctor.
- Patient dressed in cotton gown and given instructions.
- Dark adaption made by radiologist and technician. (This is usually done the first thing in the morning by putting on the goggles.)
- Preliminary fluoroscopy by doctor. Technician stirs solution and hands it to patient who will hold it at shoulder level with left hand.
- Patient drinks solution; doctor fluoroscopes and takes spot-films as he examines. Doctor marks patient with skin pencil.
- Radiographic films taken in posterior-anterior, posterior-anterior oblique, anterior-posterior or right lateral as ordered. Films made in either erect or recumbent positions.
- After first films are taken, additional films will be taken at one, five, or twenty-four hours after meal or as the doctor orders.

BARIUM ENEMA

The barium enema is used to visualize the large intestines. The medium is injected into the rectum with enema apparatus under fluoroscopic control. There are two methods used. One is the single medium of a barium sulfate solution. The other is the use of air injected into the colon after the solution has been expelled. The air

injection is called the double contrast method. The barium that is left in the colon is pressed against the sides of the tube and gives a very clear outline of the large intestine.

PATIENT PREPARATION. Preparation of the patient starts with scheduling the examination in the morning. The patient is advised to restrict himself to light meals and is given a laxative on the night before the examination. On the morning of the examination, he is given a clear water enema at least 3 hours before the examination. An enema will cause a slight irritation to the mucosal lining of the colon, so the enema should be given early enough to let this irritation subside before the regular examination begins. Instruction is given to the patient as to what is happening and what he is expected to do.

SOLUTION. The barium enema solution is made prior to the time of the examination. It will be a mixture of approximately 6 to 8 ounces of barium sulfate to one quart of water. You should fix at least two quarts of solution. Sometimes an ounce or two of acacia is mixed to help suspend the mixture in the colon. The water should be about 85 to 90 degrees. This temperature is lower than the body heat and will stop some of the peristalsis in the colon. Inhibiting the peristaltic action is helpful in allowing your patient to retain the enema longer.

PREPARING EQUIPMENT. Preparing the equipment is one of the main duties you will have. The patient is given the enema on a horizontal table, so the table is placed in a horizontal position or sometimes in a slight Trendelenburg position. The barium sulfate solution is mixed as directed. You will need an enema can, rubber tubing, a disposable enema tip, a rubber sheet or towel to prevent any material from getting on your table, a kidney basin, petroleum jelly for the enema tip and an enema standard. Any film that you will need should be available. The machine is set for fluoroscopy. The lead aprons, lead gloves and other equipment used in fluoroscopy are made ready for the doctor.

THE EXAMINATION. The examination begins when the doctor is fully adapted to the darkness. You will insert the enema tube, or have the patient insert the tube, into the rectum. This is done just before the doctor is to begin the examination. Before insertion of the tube, the solution is poured into the enema can. A little solution is run through the tube into the basin to expel the air. You will stay in the room and administer the solution as directed by the doctor. If the patient feels cramps he should breathe deeply or the doctor will tell you when to stop the flow of the solution. The doctor will observe the filling of the colon and will give you orders when to stop the flow of the solution. The patient will be on his stomach in the Sims position when the enema is started. Later the doctor may have him roll over on his back without removing the enema tip. Whatever is done you should be sure that you know how your doctor performs his procedures. Because you will be doing this in the dark you should try to develop as much teamwork as possible with your doctor. After the doctor has fluoroscoped the patient you are ready to take the radiographs. The enema tip is removed and the patient retains the enema while the first films are made.

POSITIONS. Positions used in the examination of the colon will be the posterior-anterior and the anterior-posterior. You will also use obliques for the sigmoid section and left laterals for the rectum. Your doctor will order those films which he wants. There may be other views that he will ask you to take for him so, again, each case will be individual. After films of the filled colon have been taken, the enema is expelled and post-evacuation films are exposed.

DOUBLE CONTRAST METHOD. The double contrast method will have a few more steps to it. The patient is allowed to expel the barium and is then returned to the table. The enema tube is inserted and air is injected into the colon by the doctor. Or the doctor will let the colon fill until the solution reaches the splenic flexure and then, putting the can on the floor, allow the barium to run back into it. This will leave a thin stream of barium in the colon and then the patient is rolled from side to side so the barium will coat the colon. Air is injected into the colon forcing the remaining barium against the mucosal lining. Films are taken in the posterior-anterior and anterior-posterior positions.

COMPLICATIONS. Complications can arise in the enema administration of the barium solutions. Usually this is the expelling of the solution before the examination is completed. The anal sphincter may not be able to control the solution. This may occur in old people, young children or in cases where weak control is apparent. This is solved by a number of different methods and equipment. Mostly the use of a rectal tube with a suspending balloon is used. This type of tube has a balloon which is blown up inside of the rectum and blocks the return of the solution. Another means is to place a pad at the anus so the patient can press the anal opening and hold the solution in the colon. There are also enema tubes with a half ball pad attached so pressure can be applied to the anus. The doctor is responsible for the amount of injection of either barium solution or air, and the complications that can arise from this procedure.

The main thing that pertains to the technician is cleaning up, of expelled solutions, from his film, table and equipment. You must be sure that you have complete control of yourself if this happens to you. The patient will suffer enough embarrassment without admonitions and looks of disgust from the technician. However, the technician should keep watch over the patient, encouraging him to retain the solution as long as possible and when it is apparent that this is no longer possible, allow him access rapidly to a restroom. You should perform your examinations quickly, making sure that each movement is necessary.

A SHORT REVIEW

- The patient is scheduled for the examination in the morning.

- The patient is restricted to a light meal in the evening before the examination. The doctor may order a laxative to be taken that night. A cleansing enema may be ordered also. In the morning the patient will be given a clear water enema at least 3 hours before the examination.

- The technician will set the equipment for the examination. He will mix a solution of 6 to 8 ounces of barium to 1 quart of water. The water will be about 85 to 90 degrees Fahrenheit. An ounce of acacia may be added to solution. (Mix as directed by your doctor).

- The patient will be dressed in the cotton gown provided for him.

- The patient is positioned in the Sims position and all the necessary equipment for the administration of the enema is readied.

- The enema can is filled with solution. A little solution is run through the tube to expel the air and to check for free flow.

- The enema tip is lubricated with petroleum jelly and either the patient or the technician will insert the instrument into the rectum.
- At a signal from the doctor the technician will allow the barium solution to flow. The doctor will watch the filling.
- After fluoroscoping, the patient will either be positioned with a filled colon in the posterior-anterior or anterior-posterior position, or the enema is expelled and air injected into the colon. Then the films are taken.
- In cases where only the contrast medium was used the films are taken with a filled colon; the colon is then emptied and post-evacuation film is taken.

## BEHIND AND AHEAD

You now know how to perform the examinations for the esophagus, GI Series and barium enema. You should take every opportunity you can to see these examinations and to help in preparing for them. You have some idea of how the barium is mixed in each case, what procedures the doctor is responsible for, and what you have to prepare and do during these examinations. You know what positions are used for the examination of the esophagus, stomach, small intestines, large intestines, sigmoid colon and rectum.

Ahead you will learn how contrast medium is injected into the lungs so the bronchial tree can be examined. As with other examinations the doctor does the main procedures and the technician assists as he is needed and takes the films.

## BRONCHOGRAPHY

An examination that is done fairly frequently in the larger hospitals is bronchography. The procedures are primarily the responsibility of the doctor. He will perform any necessary anesthetization, inject the medium and order the films that will show him what he wants to see. You will prepare the medium, instruments and assist as you are needed. You will also take the required films.

Bronchography is the injection of a contrast medium into the bronchial tree of the lungs. It is performed for visualization of bronchiectasis, lung cavities, or growths.

### CONTRAST MEDIA IN BRONCHOGRAPHY

LIPIODAL. Lipiodal is one of the most common contrast media used in bronchography. It is an iodized poppy-seed oil which contains about 40% iodine. The medium is a viscous, oily liquid with an onion or garlic odor. Lipiodal will decompose when subjected to air or sunlight. When it darkens from such exposure it should not

be used. The patient tolerates the medium well. It is absorbed very slowly and isn't irritating. The amount given will be between 10 cc. to 20 cc. or even more. This will be determined by your doctor. The medium comes in ampules of 10 cc. and multiple dose vials of 20 cc.

IODOCHLORAL. Iodochloral is another medium used for bronchography. It is an iodized and chlorinated peanut oil. It contains 27% iodine. It comes in bottles of 20 cc. One bottle is the usual amount prepared for injection.

## PREPARATION OF EQUIPMENT

You may not be required to set up the equipment tray, but you should become familiar with it in cases where you might have to do this task. It contains:

- Cocaine - - local anesthesia
- Atomizer - - for spraying anesthesia
- Wooden or metal applicators
- Laryngeal syringe and cannula
- Laryngeal mirror
- Head mirror
- Warm water - - for warming medium
- 20 cc. Luer Lock syringe
- Large caliber ureteral catheter
- Kidney basin for patient
- Sterile gauze
- Cotton pledges

## TECHNIQUES USED IN BRONCHOGRAPHY

There are two methods you will see used for the injection of the contrast medium. The equipment that is used will depend upon which method is used.

SUPRA-GLOTTIC METHOD. The supra-glottic method is the procedure in which the medium is dropped on the posterior surface of the tongue. It will run from the back of the tongue into the trachea and be aspirated into the bronchi.

The patient is dressed in a cotton gown ready for the examination. A chair is built up on one side with blocks or the patient is placed on the table in a leaning position. Whichever position is used the head of the patient is kept erect so the oil will flow into the glottis. The leaning position will allow the oil to run into the side of the

lung toward which the patient is positioned.

The doctor will either spray or paint the patient's throat with cocaine or some other suitable anesthesia. You must warn your patient not to eat or drink anything while the throat is without feeling. (If you do not, he may eat or drink and pass the material into the lung instead of the esophagus. You can fully understand how disastrous the results of that would be. The doctor will grasp the patient's tongue after he deadens the throat and injects the Lipiodal, in the 20 cc. syringe with the cannula, onto the back of the tongue. You will have to see that the medium is warmed enough to be easily drawn into the syringe and ejected from the syringe.

With the patient in the seated position the lower lobes of the lung will be filled. If the doctor wants to fill the upper lobes the patient is turned on the proper side and the table is placed in a Trendelenburg position so that gravity will place the oil in the upper lobes. The injection of this medium may be done under fluoroscopic control, depending upon your doctor or the patient's condition.

After the patient has had his lungs injected you will take your films. It is important that you obtain the co-operation of your patient at the beginning of the examination so that he will attempt to keep from coughing up the medium. This will be one of your major problems unless your patient knows what will happen. Keep encouraging him to retain the medium until you have all the films that you will require. Usually the injection is made quickly so the patient can be radiographed immediately.

TRACHEAL CATHETERIZATION METHOD. In this method the medium is injected through the ureteral catheter which has been passed into the trachea under fluoroscopic control.

The procedure of anesthetizing the larnyx is performed by the doctor. The patient will usually be seated and leaning toward the side to be examined if the lower lobes are to be filled. For filling the upper lobes the patient will be in a lateral recumbent position on the table with the table in a Trendelenburg position. This method is used on children and young infants.

## TAKING YOUR FILMS

Once the injection of the medium has been completed you radiograph the patient. You will use the normal positions such as the PA, AP, obliques or laterals as directed by the doctor. If possible make sure that you know beforehand what films the doctor wants. Speed is important because it may be difficult for the patient to keep from coughing and removing the medium from the lungs.

After the films have been taken, the patient is free to expel as much of the medium as possible. There will be a small amount left in the lung which will eventually be absorbed. The period of time for this absorption will vary from person to person.

## HYSTEROSALPINGOGRAPHY

This examination is done on the female patient for visualization of the uterus,

fallopian tubes and ovaries. It is used to check the opening of the passages in the fallopian tubes or it can be used to open them if they are closed.

You will probably not be required to assist in the injection of the media in these cases. A nurse or a female technician is used in normal procedures. As an X-ray technician you will only take the films. Even in this task, you may find that the doctor will make the required exposures.

The examination is done, in most cases, on a cystoscopic table that is equipped with stirrups. The patient requires a cleansing enema the night before the examination and another in the morning before the medium is injected.

## EQUIPMENT USED FOR HYSTEROSALPINGOGRAPHY

- Bivalve vaginal speculum
- Uterine dressing forceps
- 20 cc. syringe
- Cervical cannula with rubber stopper
- Contrast media (different types can be used)
- Mercury manometer to test pressure
- Tenaculum

## CONTRAST MEDIA USED FOR HYSTEROSALPINGOGRAPHY

LIPIODAL. Lipiodal is a medium that can be used in this examination. However, the doctor will use caution in preventing the material from entering the circulation. A fat embolism may result if the medium enters the blood stream. An embolism is the blocking of an artery and vein with a clot or substance such as the medium. Injury can be incurred by blocking the circulation.

SALPIX. Salpix is a contrast medium that has viscous properties needed for the examination, but is water soluble and will absorb if any gets into the peritoneal cavity. The medium comes in packages of 6 vials containing 6 cc. each and others with 4 vials containing 10 cc. of the medium.

SKIODAN ACACIA. Skiodan acacia solution is a contrast medium made for hysterosalpingography only. The acacia provides the viscous element needed and the skiodan provides the opacity. It comes in boxes of 1 ampule of 10 cc.

## INJECTION PROCEDURE

The patient is placed on a cystoscopic table with the knees resting in stirrups. The doctor inserts the vaginal speculum. This instrument will open the vaginal passage so that the cervix of the uterus is visible. With the tenaculum forceps he will

hold the cervix and insert the thin cannula into the cervix canal of the uterus. A coned rubber stopper is pushed along the cannula and plugs the cervical opening so the medium cannot be released. The doctor will inject the contrast media through the cannula under slight pressure. About 10 cc. of the medium is used.

### RADIOGRAPHIC FILMS

The technician will take films using the ordinary pelvic positioning techniques. There may be necessity for obliques or a posterior-anterior view, but the doctor will let you know what he needs. The films are sometimes taken at intervals during the injection, but usually immediately after the injection is made.

## BEHIND AND AHEAD

You have now learned the ten most frequent examinations that are done in the Air Force. "Frequent" means those examinations that you will more likely perform in Air Force clinics. You know how to do a GB Series, GI Series, intravenous pyelograms, cystograms, barium enemas, bronchograms, cholangiograms and hysterosalpingograms.

Ahead of you are an additional series of examinations which you will see performed in the Air Force. You will become familiar with examinations such as sialograms, myelograms, ventriculograms, vasograms, abdominal anteriograms, encephlograms, angiocardiograms, and cerebral angiograms. Most of these examinations are performed by the radiologist or a specially skilled physician. The technician need only be familiar with the examination so that he can assist as he is needed. You cannot be skilled in these examinations until you have done them often. In a few clinics you may be able to get all the necessary training you can use, but in many clinics these procedures are rarely, if ever, done. This does not mean, however, that you can ignore them. You should keep current on the literature of your field so that you are not caught short when you are required to set up for one of these procedures. When you know where to look for the information on them you have half your battle won.

## SIALOGRAPHY

Sialography is the examination of the parotid and submaxillary glands. It is performed to show calculi and to see if the ducts are open. Lipiodal is injected into the ducts which open into the mouth. The doctor will use a blunt end needle or cannula. To find the tiny opening of the duct you will probably have your patient take some salt or a few drops of lemon juice. These things will cause the duct to send out saliva and the doctor can see where the ducts are.

The patient has the examination explained to him. His mouth is disinfected with a disinfectant solution of your doctor's choosing. The doctor will find the duct and inject the medium. He will use from 1 cc. to 5 cc. of the medium. It will be ne-

cessary to warm the medium in warm water so it will run through the needle properly. He will inject until the patient complains of pain in the glands. After the injection is made you will take radiographs of the injected gland.

For the parotid gland you will use the normal skull positions and other views as directed by the doctor. In the positioning of the submaxillary glands you will use the position of the mandible. It is important that the chin be extended so that the glands are not superimposed over the cervical spine.

## HIP NAILING

Hip nailings are done in the operating room. This procedure is performed under strict surgical sterile technique.

In these operations the orthopedic surgeon is attempting to insert a metal pin into the neck and head of the femur to immoblize fractures of the upper end of the femur. He uses X-ray films to determine how well he has the pins in place. He may need a number of films if the case is difficult.

Prior to the operation you should see the chief nurse and find out exactly where your position should be during the operation. She will instruct you on how to maintain the sterile field around the operating area. It is your responsibility to follow her instructions and keep constantly alert.

### PLACEMENT OF MACHINES

Also before the operation begins you will usually install two portable X-ray machines in the operating area. These machines will be covered with sterile draping. One machine will be set up for posterior-anterior views of the hip and the other arranged to take lateral views of the hip. You may be required to swing your tube in and out of position for the lateral views. A point to remember is to work under the draping at all times and never reach over the sterile area. Anything below the waist can be considered unsterile.

### FILM POSITIONING

Positioning of the film will be performed either by the doctor, nurse, or yourself depending on your doctor's preference. The film is put into a sterile case, a wrapper, or a pillowcase.

You should allow yourself practice in setting up techniques and going through the motions of the procedure so that you can perform with maximum accuracy and speed. Because this is an operation it will be necessary to be ready to take the examinations quickly. This does not mean, however, that you rush so fast you forget what you are doing. You must maintain calmness and efficiency at all times.

## PROCESSING AFTER EXPOSURE

When the exposures have been taken you will take them immediately to the darkroom for processing. These films may be processed in a special darkroom in or near the operating room. You will use the fast techniques that you have learned in your chapter on Darkroom Techniques. As soon as the films are ready for viewing return them to the doctor. When the doctor has seen the films they are returned to the fixer to harden properly.

A WORD OF CAUTION. Gaseous anesthesia can be dangerous. If it is being used you will take all necessary and possible precautions described to you by the anesthetist. The basic danger is ELECTROSTATIC SPARK! Some of the fundamental things to practice are:

- Cover your hair.
- Wear cotton uniforms.
- See that plugs and sockets are explosion proof so that your connections cannot be accidentally pulled apart.
- Avoid all unnecessary motion around anesthetist and patient's head. You won't generally be in this area but be aware of this fact.
- See that all leads are grounded.
- If you ever have to get close or make contact with the patient or anesthetist be sure to touch the anesthetist's stool or operating table AT LEAST TWO FEET FROM THE FACE MASK. This will allow any discharge to take place before you are close to the patient or machine.
- Use only such equipment that has been designed for use in a hazardous area.
- Make sure that all equipment used in surgery is checked monthly by the maintenance section.
- Stop using immediately any faulty equipment and report it so it can be removed and repaired.
- Do not smoke or create a flame while in the room.
- SHOULD FIRE EVER BE SEEN IN THE OPERATING ROOM - REMOVE THE BURNING ARTICLE QUICKLY from the vicinity of an oxygen tank or anesthesia machine. Put it out. Be sure you know where the fire extinguishers and alarms are. Although the surgery personnel are fully aware of these things you will still be in an area where you might have to act.

To assure that all possibility of explosion is avoided will take constant alertness and practice of the above procedures. You will find that when X-ray is used that the anesthesia is usually non-inflammable, but the necessary precautions must be taken in any event.

## MYELOGRAPHY

Myelography is the visualization of the spinal canal. It is done to show ruptured intervertebral discs or spinal tumors. Pantopaque is the contrast medium that is used. This procedure is done entirely by the doctor or radiologist. It consists of injection of the medium, fluoroscoping and spot-filming. You will have little responsibility in this examination with the exception of preparing the patient and medium and bringing films to the doctor as required.

The technician will see that there is a lumbar puncture set available (See Nursing Chapter). The patient can be positioned prone, lateral recumbent or sitting erect. This will be determined by the doctor's preference. The area of the puncture will be prepared and swabbed with an antiseptic solution.

The Pantopaque comes in vials of 3 cc. Your doctor will use from 2 cc. to 12 cc., but the average amount used in the examination is 6 cc.

During the initial puncture the doctor will usually take specimens of the spinal fluid. These specimens are placed in test tubes, labeled and sent to the laboratory. After the samples are taken the doctor will inject the Pantopaque under fluoroscopic control. The screen is locked in position because the lumbar puncture needle remains in position during the examination and the doctor will not want to accidentally hit the needle with the screen. He will use the tilting mechanism of the table to spread the medium up or down the column. If he is to examine the upper column of the cervical region he will have the patient hyperextend his head so the medium cannot get into the skull. As he fluoroscopes he will take a series of spot films of areas which he wishes to study. You will supply him with the film as he requests it.

After the examination is completed the doctor will attempt to remove all of the Pantopaque from the column. He will use a 2 cc. syringe because it will not create as much suction as a large syringe does. This is necessary because the Pantopaque requires a careful technique for its removal. Of course, it is not always possible to remove every drop so don't be alarmed if you see films with some medium still in the column.

## VENTRICULOGRAPHY

Ventriculography is an examination to show the ventricles of the brain. The procedure is done to detect brain tumors in or encroaching on the ventricles. If a ventricle is displaced it may indicate pathology. The contrast medium used is air. The injection of this air is done in the operating room under strictly surgical sterile technique. You will be required to take the films either in the operating room or your X-ray clinic. Usually this is done in the clinic. The injection is made and then the patient is brought to the clinic on a surgical cart.

Review your chapter on anatomy and go over the area devoted to the ventricles of the brain. As you know they are filled with cerebrospinal fluid. This fluid is removed and air is injected to take its place. The air is lighter than the surrounding tissue so the ventricles can be seen. You must also keep in mind that air will rise.

This will mean that some of your positions will require that you give the air time enough to enter the ventricle you wish to show. Your main task in this examination is the taking of the films.

Your patient will appear in a groggy state. He may also complain of severe headache if he is conscious. Perform the examination gently and with calmness. You will try to have all your actions pre-planned so the examination can be done quickly. In some instances your patient cannot hear or grasp your instructions so many times you will have to do your examination without his help. Do not become exasperated- it will not help you or your patient. You may need help to hold your patient in position so get a nurse or wardman to do this. You may also encounter various devices that can be used to immobilize the head in the proper positions.

## RADIOGRAPHIC POSITIONS

You will find that there will be many variations in the positions you will use and the number of films that you will be required to take. It will depend upon which part of the ventricles interest the doctor. If, for instance, the posterior horn of the lateral ventricles is wanted, the patient will be placed with his face down. The air will rise to the posterior horns. Reverse the position and the air will be in the anterior horns. In any examination you will take pairs of films at right angles to each other. Your tube can be above or below the table and, of course, horizontal on either side. You have to think a little on these positions so do not be confused. You will hear terms such as "brow up" and "brow down". This simply means the body is prone or supine.

| | |
|---|---|
| BROW UP | Take an AP, right and left lateral without moving patient. You can place the film over the face and place tube under the table for a PA. |
| BROW DOWN | Take a PA, right and left lateral without moving patient. Film on back of head and tube under table for AP. |
| LATERAL | Place patient's head in lateral position. Take right and left lateral, AP and PA without moving patient. If this is done with the patient on the right side, it can be done also for the left side. Also the procedure can be done with the patient in a prone or supine body position. |
| SUBMENTOVERTEX | This position is used to show the third ventricle. By extending the head back the air flows into the third ventricle. You can take this view and right and left laterals from this position. |
| FLEXED VERTICO-SUBMENTAL | This is the reverse of the submentovertex with the chest built up and the patient tucking his chin under. You take right and left laterals and an occipito-frontal view. This may not be seen frequently. |

As you see there can be a number of positions. You will have to find out the

positions that your doctor wants. Then you must make up some identification tapes which will designate which position is being demonstrated. Keep a list of those positions that can be done with the patient in the same position and do all the views required before you move your patient to another position. Also give the air time to get into the ventricle you are examining. Be sure that your patient's head is immobilized. Use the shortest exposures that are possible for your technique.

## ENCEPHALOGRAPHY

Encephalography is another method used to demonstrate the ventricles of the brain by injecting air as a contrast medium. Instead of drilling through the skull and passing a needle through the brain to the ventricles, a lumbar puncture is made and air is injected into the spinal column. The air will rise through the column and fill the ventricles. This method is also used to see if the spinal column is blocked below the ventricles. If the air does not pass into the ventricles the area where it stops may indicate pathology.

In this procedure, the patient is given a lumbar puncture while sitting in a chair. The technician will prepare the tray so it will be available to the doctor. The doctor will draw out spinal fluid and use some of it for specimens. These specimens are placed in test tubes, labeled and sent to the laboratory. The doctor will inject the air into the spinal column and it will pass up to the ventricles. Films are taken after the injection of the air.

The patient may remain erect for some views, but generally he will be placed on the table in a recumbent position. The views taken will be similar to those used for ventriculography.

## PNEUMOPERITONEAL EXAMINATIONS

Pneumoperitoneal examinations employ the injection of air into the abdomen to separate the organs in this region. The doctor will inject air under fluoroscopic control. The air, being lighter than the surrounding tissue, will allow the organs to be outlined. This procedure is done under sterile technique. The technician will be required to take the films, but the rest of the procedure is done by the doctor. The injection is made lateral to the umbilicus. The skin is prepared over the area. The doctor will inject a local anesthesia. Using an ordinary lumbar puncture needle he will penetrate the abdominal wall and pump air into the abdomen. After the air is injected the needle is withdrawn and the wound bandaged. The patient is either radiographed immediately after the injection of air, if the procedure is done in the clinic, or is brought to the clinic for the films.

### RADIOGRAPHIC POSITIONS

The thing to keep in mind is that the air will rise. The doctor may roll the patient during the injection to let the air surround each organ, but when you position the

patient this air will be displaced. You can take PA, AP, lateral recumbent or decubitus projections of the abdomen.

Where the horizontal ray is used the patient should be built up so that the part is on the film. Use a block or firm pillows to do this. Sometimes you may have the patient take some carbonated drink so the wall of the stomach is outlined into the air space.

## ANGIOCARDIOGRAPHY

Angiocardiography is the visualization of the heart and the great vessels surrounding the heart. A contrast medium is injected into the veins and the medium is concentrated in the heart. Films are taken at various intervals to record the various areas of the heart and vessels as the medium reveals them.

This examination is done to show any pathology of the heart or great vessels. It will also reveal certain conditions that are outside of these structures.

### CIRCULATION TEST

Films have to be taken at the right moment. You need to know how long it will take for the medium to reach each area of the heart. To find the time it takes for the medium to reach certain areas you must do a circulation time test. There are a number of different substances you can use for this test.

Ether can be used to test for circulation in the right side of the heart. As you remember the blood returns from the body in the inferior and superior vena cava. If the solution is injected into the blood stream through the arm, the medium will enter from the superior vena cava into the right atrium. From the right atrium it will pass through the right ventricle into the pulmonary veins. As the veins enter the lungs the ether is expelled as the air is exchanged and you can smell the ether on the patient's breath. The time that it takes to present itself will allow your doctor to estimate the time the medium is entering each area and when to expose the films. Thus ether can be used to test the circulation time through the right side of the heart.

Sodium cyanide solution can be used to check the circulation through the left side of the heart. It works on the principle of acute, quick, and instant temporary hypernea. When it reaches the heart the patient will usually gasp sharply and his breathing will become rapid. The circulation time will be from the time of injection to the appearance of this rapid breathing.

Also the Air Force clinics use Decholin. It is a drug used for circulation test which causes the patient to experience a bitter taste in his mouth.

In any of these, however, it will be up to the doctor to tell you when to expose your film. You find this done in many ways.

## CONTRAST MEDIA USED

You will use a more concentrated solution of the various media. Diodrast 70%, Neo-Iopax 75% and Urokon Sodium 70% are three of the media used. The choice as to which is used will be up to your doctor. An adult will be examined with 40 to 50 cc. of the solution. 1 to 1.5 cc. per kilogram of body weight is used in figuring the dosage for children.

The patient should be told of the various reactions that he may experience. Some of these are heat, weakness, headache and nausea. These reactions will last for a short time. Also it is common for the patient to experience a chemical thrombosis along the arm. This is not particulary dangerous. It will occur as a firm, painless, tender cord which can extend from the site of the injection up to the axilla. As with any examination, the severity of reaction must be determined by the doctor. Oxygen and other stimulating drugs like adrenalin will always be present for emergency use.

## EQUIPMENT

Angiocardiography will use some special types of equipment. This equipment may be available in some clinics. If the equipment isn't available, the clinic will improvise to satisfy the requirements. One of the essential features of the examination is the rapid injection of the medium into the circulation. If it were not injected rapidly enough the medium would not be concentrated sufficiently to make the vessels opaque. The other essential feature is a means of changing films fast enough to take a number of them in a relatively short time.

The tray set up will include the following list of items.

- 2 ampules of 25 cc. each of medium
- Tourniquet
- Number 11 scapel blade and handle
- 1% procaine
- 2 cc. syringe and assorted needles
- Robb-Steinberg needle
- Antiseptic
- Oxygen apparatus
- Saline Solution
- Tape

Film equipment should allow for a number of films to be exposed rapidly. Some of the devices are:

- Fairchild, Type F-280A Roll Film Cassette
- Single Film Method
- Bi-plane equipment

## PROCEDURE

The doctor or nurse will prepare the patient for the injection. The antecubital area of the elbow is prepared with antiseptic. The 2 cc. syringe is filled with pro-

caine solution and injected over the vein selected. A 2 to 5 mm. incision is made over the vein. The tourniquet is applied. The Robb-Steinberg needle is placed in the vein. The placement of the needle is checked by opening the stopcock on the needle hilt and letting blood drip onto a gauze pad. A test injection of saline solution is made. The stopcock is closed and needle taped to the arm until the doctor is ready for injection of the dye. Of course, the test for circulation has been performed prior to this preparation.

The technician arranges the apparatus that he is going to use and makes sure that he has sufficient films available. He will also have made arrangements for the films to be developed immediately so the doctor can see them. He will set up the machine for the proper techniques. And he will have worked with the doctor on the signals to be used for taking the exposures.

The patient will be seated before the cassette changer or lying over the film device. If the patient is seated the arm of the patient will be held up and at a forty-five degree angle with the anterior surface of the forearm facing the doctor. The doctor will take the medium-filled syringe and fit it into the needle already in the patient's vein. The doctor is to be protected by using a cone to cover the area of exposure, and lead aprons.

## RADIOGRAPHIC FILMS

The number of exposures that can be made will depend upon the type of cassette holder available. Also you may require two technicians for the examination, if the device is to be operated manually. One technician will pull or replace the films and the other will make the exposures.

With the patient in position the doctor will tell the patient to "breathe out" and then to immediately "breathe in". On the word "in" you will begin to make your exposures. The doctor will try to inject the medium within a period of 1 to 1-1/2 seconds. The patient will be holding his breath through the series of films. If you have an automatic device it will all be over in 5 to 6 seconds after the injection is finished.

If you have an improvised device requiring the films to be pulled manually, the doctor will say "shoot" each time he wants a film taken. The one technician pulling the films will take the strings and pull each cassette that has been exposed out of the field for the next exposure. Because most machines that will be used for these examinations will have a second delay before the exposure is made, you will be getting one exposure a second. On some machines, however, instantaneous exposures can be made and the only wait necessary will be for the removal of exposed films. Speed of exposure, as you remember, is one of the essential techniques to be used for these examinations.

After the exposures are completed they are immediately developed so the doctor can see if he has successfully demonstrated what he wanted. This development is done with a rapid process or as an emergency wet film. The preparation must be made before the examination starts so that the darkroom will be free during the time the examination is in progress.

The patient is separated from the injection apparatus after the films have been checked. A pressure bandage is placed over the wound for an hour or two.

## CEREBRAL ANGIOGRAPHY

This examination follows the same principles as the procedure that has just been explained. However, the injection is made at the common carotid artery in the neck. This injection can be done either by just puncturing the skin like you do for a regular intravenous injection, or the artery can be exposed by making an incision over the site and then inserting the needle. The doctor will be responsible for the injection.

The procedure is done to show the circulation system of the skull. The medium will take about 6 seconds to pass around the skull. This again will indicate that time is an essential factor in the examination. The doctor must inject the medium rapidly.

The patient will be in the supine recumbent position. His head will rest on the cassette changing device. The side to be examined will be remote from the film so the doctor can inject into the artery. You will take the films with the patient in the supine position, but with the head in a lateral position. You may also take an anterior-posterior projection. Generally you will take two lateral views and two anterior-posterior views. You will take the first film just as the doctor finishes the injection. This view will show the arterial circulation. Another exposure is made 3 to 6 seconds later and this will show the venous circulation. The second film will show less concentration of the medium because it is more diluted as the amount of circulation is increased. After the laterals are taken the patient is carefully positioned into the anterior-posterior position and a second injection is made. Films are exposed in the same manner as the laterals. You may need two technicians, one to expose the film and the other to remove the exposed film. Your timing and teamwork with the doctor is very important.

## ABDOMINAL ARTERIOGRAPHY

This, again, is the injection of medium into the blood stream to outline circulation. However, this procedure is used to show the abdominal aorta and its branches. The injection and preparation of the patient is the responsibility of the doctor.

Prior to the examination the patient is given a cleansing enema to remove material in the colon. The patient is placed on the table in the supine position. The patient is given a sedative before the examination begins. A preliminary film is made to determine the cleanliness of the colon.

The procedure is done under sterile technique. The skin is prepared around the site of puncture. The patient is positioned so the doctor can inject at the posterior and lateral side. The site is about a hand's breadth from the spinous process below the twelfth rib on the left side.

The patient is positioned according to the wishes of the physician and the method or site of injection. Usually you will include the entire abdominal area. The interest will be in the region where the abdominal aorta branches into the common iliac arteries or possibly the portal system.

As you have seen, this examination is much like the others involving the circulatory system. You will be there to assist as needed and will be under the constant supervision of a physician or radiologist.

## BEHIND AND AHEAD

You have just studied the more uncommon procedures. You need not be surprised if you do not perform these in your clinic. They are examinations which call for skill and special equipment. These procedures will be done in the larger Air Force hospitals or in centers where there are qualified personnel. You know something, now, of sialography, hip nailing, myelography, ventriculography, encephalography, pneumoperitoneal examinations, and circulatory examinations.

Your next chapter will be concerned with special techniques. You will learn how to do stereoscopic examinations, pelvimetries, locate foreign bodies and how to operate a photofluorographic unit.

## QUESTIONS

1. What is fluoroscopy?

2. Explain the construction of the fluoroscopic screen and how it functions.

3. Explain how the spot-film device works.

4. What is dark adaption and why is it important?

5. What will be your primary duties in fluoroscopic examinations?

6. What type of protection do you use in fluoroscopy?

7. What is contrast medium and what forms do contrast media assume?

8. Name at least ten contrast media used in the Air Force by trade name or chemical name.

9. List at least ten reactions that can occur from contrast media.

10. What is cholecystography? What is cholangiography?

11. What is the Graham-Cole Test?

12. Why is the gall bladder examined? Name some conditions.

13. Name three contrast media that are used in gall bladder examinations.

14. Describe the instructions that must be given to the patients concerning the taking of contrast media for the gall bladder.

15. Explain the procedure used in taking the films of the gall bladder.

16. What are some of the names used in describing examinations of the urinary system?

17. What are some of the conditions the urinary system is examined for? Discuss four media that are used in the examination of the urinary tract.

18. How is a patient prepared for an examination of the urinary tract?

19. What is a sensitivity test and how can you perform them?

20. Describe the procedure you would use in performing an IVP.

21. Describe the procedure you would use in performing a retrograde pyelogram.

22. What is cystography and how is it performed?

23. Name at least four types of examinations performed for the digestive system and the contrast media used.

24. Explain the procedure used in the examination of the esophagus.

25. Explain the procedure used in the GI Series examination.

26. Explain the procedure used in the BE examination.

27. What is a double contrast enema and how is it performed?

28. What is bronchography? What contrast medium is used for the bronchogram?

29. What techniques are used to inject the media for a bronchogram?

30. What positions do you use to take the lungs after the media has been injected in a bronchogram?

31. What is hysterosalpingography?

32. Explain the procedure used in the examination of the female organs.

33. What is sialography?

34. What positions are used for the sialogram?

35. Explain the procedure used in examinations during a hip nailing operation.

36. What is the basic danger of an X-ray unit in surgery during an operation?

37. What is myelography?

38. What are your duties during myelography?

39. Explain the procedures used to perform myelograms.

40. What is ventriculography?

41. Describe the procedures used in performing ventriculograms.

42. Explain the procedure used in performing encephalography examinations.

43. Describe how peritoneal examinations are performed.

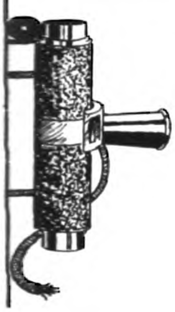
44. What is angiocardiography?

45. What materials are used to perform circulation tests and what does each of these materials do?

46. Explain the procedure used in the angiocardiography examination.

47. Explain the procedures used in the cerebral angiography examination.

48. Explain the procedures used in the abdominal arteriography examination.



# CHAPTER 10

## SPECIAL TECHNIQUES

There are a number of special techniques used in X-ray. These techniques are used to provide information that is not ordinarily obtained in routine procedures. In this section you are going to learn about stereoscopy, pelvimetries, foreign body localizations, and photofluorographic surveys. These techniques require the use of specialized devices. Each of these techniques will require a certain amount of experience before you can become proficient. You will find that there are variations in the way these techniques are done. For instance, pelvimetries can be performed using five or six different techniques. You will find it necessary to learn these variations as you go from clinic to clinic. Your doctor may prefer one method over the other and you will need to learn the examination according to his wishes. You will be shown the basic fundamentals of these various techniques so that later on you can recognize the modifications used by other clinics.

### STEREOSCOPY

Stereoscopy is the technique of presenting the structure so that it appears to have depth. This technique is used when there is difficulty in getting views at right angles to each other, and when depth is required. This technique provides the doctor with a three dimensional view of the part.

Stereoscopy requires the use of two films. Instead of centering the tube directly over a particular centering spot, the tube is placed off center on either side of this spot. In this way, you will be taking two slightly different views of the part. When these two views are placed on a viewing device, they will come together and you will have the sensation of depth. Stereoscopy is used more extensively in chest and skull work.

You will be able to adjust your tube column for three different types of stereoscopy. You can stereo across your table, up and down the long way of your table, and in chest work, stereo up and down in the vertical position. The stereo mechanism is manually operated in the table shifts, but is mechanical in the vertical shift when the stereo button is pushed.

Shifts of the tube are required to give you two slightly different films. Because the eyes look at an object and see it slightly different until the image is fused together in the visual centers of the brain, the tube must see the films differently too. The tube acts like an individual eye. When the films are placed in a viewer, the eyes can then fuse the two images into a solid object that has depth. Thus, the stereoscopic technique has the tube replace the eye until the films are viewed.

## HOW STEREO IS PERFORMED

The patient is placed in the proper position as used for the routine projection. The central ray is aligned to the normal point of entry. The stereo apparatus on the tube carriage or vertical carriage is set. The tube is shifted from the original point to one side. A film is exposed. The tube is shifted to the other side and another film is exposed. The patient maintains the same position for the two exposures.

TUBE SHIFT. How much do you shift the tube? You must know how far to shift a tube before you can get a true stereo film. The viewing device is a factor in determining the amount of shift that will be needed. Also the distance between the pupils of your eyes is a factor to be considered. Of course, it will be the doctor's eyes that must be used in determining the interpupillary distance. Generally the distance between the pupils of most people is two and a half inches. The best viewing distance for the image is twenty-five inches in front of the eyes. The distance between the focal spot and the film is another factor. The ideal distance is from 25 to 28 inches. Distances from 30 to 72 inches are used in routine techniques. With these three factors, interpupillary distance, image distance, and FFD, we can find the amount of tube shift we need at various FFD's. You can use the proportion, TS:FFD::ID:IDv.

| | | |
|---|---|---|
| Tube Shift | = | X (unknown) |
| Focal-Film Distance | = | 36 inches |
| Interpupillary Distance | = | 2.5 inches |
| Image Distance | = | 25 inches |
| X : 36 :: 2.5 : 25 | | |
| 25 X | = | 90 |
| X | = | 3-3/5 inches |
| Tube Shift | = | 3-3/5 inches |

Now you have the total tube shift. Remember that you are going to use only one-half of this to either side of center, however. Another example would be the distance used for chest films, 72 inches. What shift would be required here?

| | |
|---|---|
| TS : FFD :: ID : IDv | 25 X = 180. |
| X : 72 :: 2.5 : 25 | X = 7-1/5 inches |

You can see that the tube shift on each of these problems is approximately one-tenth of the focal-film distance. You can use the one-tenth measurement as a general technique, but you will find that some persons cannot stereo unless the more accurate ratio is made.

PREDOMINANT LINES. It makes a difference how you stereo different parts of the body. This is why you need an apparatus that will stereo across the table, down and up the table and up and down vertically. The shift must be at right angles to the more prominent lines of the part. In long bones the shift is across the long axis of the bone. The skull shift is also across the part. The chest is taken with a vertical shift because the ribs are the predominant lines.

CHEST STEREO. In stereoing the chest, you will use the mechanical stereo device on the tube column. The device is set for stereo by bringing your tube down to the proper distance you normally use for chest films. The CR enters at the nipple line or 6th thoracic vertebra. The device is locked. The tube is then moved down until it stops. In most machines, this will be a six inch drop. The tube will lock. Two films are placed in the cassette changer. The patient is positioned. The technician sets the stereoscopic button or switch on his control panel. He will make the first exposure while the patient is holding an inspired breath. When this exposure is made, he will flip his stereo button or switch. The films will change places. The patient will still be holding the same position and breath. The second exposure is made and the examination is finished.

OTHER SHIFTS. Stereoscopic projections of the other parts of the body are done manually. The patient is positioned. The tube is centered. The stereo devices are locked in position. The tube or column is shifted to one side of the stereo shift. The technician makes the exposure. While the patient still holds the position, the technician will remove exposed film, place new film into position and shift the tube to the other extreme of the stereo shift. He will make his second exposure and the examination is finished.

The important thing to remember in the stereo examination is that the patient must remain in the same position for both exposures. If he moves, you will not have a stereo.

After the exposures are made, the films are sent together to the darkroom. They are processed together through the darkroom procedures.

VIEWING. In the Air Force the films are viewed with a Wheatstone stereoscope. You must know how to put the films in the viewer correctly so they will stereo. You will notice that the viewer has two illuminating boxes and a set of mirrors which can be manipulated for stereoing the films. The boxes are set 25 inches from the mirrors. The mirrors are at an angle of 90 degrees to the film. The steps given below are used when viewing through the Wheatstone stereoscope.

- The films, with the side which faced the tube facing you, are placed side by side. You must see the films as the tube saw them.

- Superimpose the films over each other. Now reverse the films so that the side that was facing the tube is now away from you.

- Up and Down Tube Shift: (Chest) With films superimposed and exposed side turned away, hold the film's at the top with the left hand and the bottom with the right hand. You will see that one image is nearer the top and the other nearer the bottom of the films.

- The image nearest the right hand or bottom of the film is placed in the right hand box.

- The image nearest the left hand or top of the film is placed in the left hand box.

- Up and Down Shift: Superimpose the films, but instead of holding them at the top and bottom, hold them with the right hand on the right side of the film and the left hand on the left side of the film.

- The image which appears close to your right hand is placed in the right hand box.

- The image which appears closer to the left hand is placed in the left hand box.

If you have aligned the films correctly, the films will appear to give an anterior-posterior view. If they are placed incorrectly, the films will appear reversed, or give you a posterior-anterior view. The identification marker will appear to be on the far side when you view the films.

Because stereoscopy is rather difficult to imagine, you should have your NCOIC give you an actual demonstration of the various stereoscopic devices on your tube. Take a stereoscopic view of a part and try to place it correctly on the viewer. By experimenting, you will be able to do the stereoscopic examination and understand more fully the principles.

## PELVIMETRIES

Pelvimetry is the examination of the birth canal of pregnant women. It is usually done in the latter months of pregnancy to determine the opening of the pelvis. It will show the measurements of the outlet and inlet and let the doctor know if the canal is large enough for normal birth or if he will have to perform a Caesarean operation.

Films are taken in a variety of positions. The preference of your doctor is your guide. He will also determine which technique you will use. This section will provide you with basic information and you will modify this information to the techniques used in your clinic.

MEASUREMENTS. The doctor is interested in the measurement of the pelvic inlet and outlet. Accurate positioning is required for accurate measuring. Accurate positioning and technique is also required because the pregnant mother should not receive more radiation than necessary. Excess radiation may cause harm to the unborn child.

Generally the doctor will be interested in four diameters. These diameters are:

- True Conjugate: This is the measurement from the top edge of the sacral prominence to the posterior middle surface of the symphysis pubis.
- Transverse Diameter: This diameter is the distance between the mid-points of the brim from side to side.
- Oblique Diameters: These measurements are from the sacro-iliac joints across to the ilio-pubic brim.
- Interspinous Diameter: This measurement is from the ischial spines transversely.

POSITIONS. The positions used in pelvimetry are basically an anterior-posterior, posterior-anterior, erect and recumbent lateral, a semi-sitting position for the superior-inferior view of the inlet, or a posterior-anterior position with the patient seated and leaning forward. You will learn of a technique later where the patient lies supine and flexes her knees and hips. A combination of these positions with various devices may be called by proper names of the doctors who devised them. You will hear of Thom's method, Colcher-Sussman, Ball or Snow's methods. Any of these methods may be modified, in regards to specific measurement, but the positions used will be similar to those mentioned above.

ANTERIOR-POSTERIOR POSITION. Use a 14 x 17 cassette placed lengthwise in a bucky tray. The patient is helped onto the table. She is placed in the supine position. A pillow is placed under the shoulders and sandbags are placed on either side of extended legs. A sandbag should be placed under the knees to reduce strain on the patient. The film is centered so that the lower border is at the level of the symphysis pubis. The central ray is directed perpendicular to the center of the film. It will usually pass directly through the umbilicus. The patient will suspend respiration after exhalation. Measure through the highest point of the abdomen. ID is placed on either side.

The patient is dressed in a cotton gown with the opening down the back. The distance will be the one preferred by the radiologist. In some examinations, the central ray is directed perpendicular to the highest point of the abdomen and then angled 25 to 30 degrees caudad (toward the feet) to the pelvis. The film is centered to coincide with the central ray.

POSTERIOR-ANTERIOR POSITION. Use a 14 x 17 cassette placed lengthwise in a bucky tray. The patient is placed in the prone position on the table. The patient is supported with pillows under the chest and pelvis so that there is no pressure on the abdomen. The film is placed so the bottom edge is at the level of the tip of the coccyx. The central ray is directed perpendicular to the center of the film. The part is measured through the central ray. The ID is placed on either side. The central ray is sometimes angled toward the head 25 to 30 degrees to investigate early pregnancy.

LATERAL POSITION. Use a 14 x 17 film placed lengthwise in the bucky tray or a vertical cassette holder.

Erect: The patient is placed in the lateral position so that the hips are slightly lateral to the midline of the film. The central ray is directed horizontally to the level of the upper edge of the hip joint. ID is placed on the posterior upper edge of the film. Measure the central ray.

Recumbent: The patient is placed in the lateral recumbent position. The patient flexes her knees and hips slightly. The film is placed so that the bottom edge is at the level of the tip of coccyx or symphysis pubis. The abdomen should be centered so that the fetus is included on the film. The central ray is directed perpendicular to the abdomen midway between the lumbar spine and the anterior edge of the abdomen.

SUPERIOR-INFERIOR PELVIC INLET. Use a 14 x 17 cassette placed crosswise in the bucky tray. The patient is seated on the table. A support is provided so that she can lean back about 40 to 60 degrees. The iliac crests are parallel to the film. The film is centered to the hip joint. The central ray is directed perpendicular to the center of the film. The patient may have sandbags under the knees for comfort and to reduce strain. In patients with large breasts that may superimpose the posterior border of the pelvis, the support should be angled back farther. Measure through the central ray. Place ID on either side.

SUPERIOR-INFERIOR PELVIC OUTLET. Use a 14 x 17 film placed crosswise in the bucky tray, or under a grid. The patient is seated on the end of the table. Her legs are spread wide apart and she leans forward gently so the abdomen goes between her legs. A chair back is placed so that she can support herself and a stool should be provided for her feet. The film is centered to the hip joint. The central ray is directed perpendicular to the mid-point of the sacrum and emerges through the pubic arch. The part is measured through the central ray. The ID is placed on either side.

These are the basic positions used to show the placement of the unborn child, to detect early pregnancy or to measure the pelvic inlet and outlet. There are certain techniques that employ various equipment to get accurate measurement of the pelvic region. This equipment compensates for the magnification that must be inevitably shown in any radiograph. The principle of this equipment is to have a known measurement of length on the film. The equipment has holes through which the X-ray can pass and expose the film. These holes are drilled one centimeter apart. By comparing the number of black spots on the film, the doctor can tell how many centimeters the different diameters extend.

## THOM'S METHOD

Thom's method of pelvimetry is one of the older techniques used in some Air Force clinics. This technique requires the use of two films. One is taken to show the pelvic inlet and the other is a lateral view. This technique has an inclined back apparatus for leaning the patient back and a lead grid or strip with pinholes punched in it. The patient assumes the seated position on the Thom's board. The plane of the pelvis is positioned so that it is parallel to the film. The film is placed in the bucky tray or under the patient crosswise. The central ray is directed perpendicular to the center of the film and exposure is made. The patient is then removed from the apparatus. The lead grid, which has pinholes every centimeter, is placed over the film and another exposure is made. There is a newer development in this grid. It is a lead strip with a series of pinholes in it that are made to show the diameter dis-

tance of the various diameters that lie above the film. For instance, the interspinous diameter between the two ischial spines is closer to the film than the true conjugate diameter (measurement between sacral prominence and posterior surface of the symphysis pubis). The rows of holes are calculated to show the true diameter of these various levels. The black dots on the film are measured, using either the strip or lead grid, and the number of dots will indicate the measurement of that particular diameter in the pelvis.

You will use the regular superior-inferior position with the Thom's apparatus. Care must be used when you are positioning the patient. The apparatus has a posterior post that is fixed and an anterior post that can be adjusted to the appropriate landmark. The grid is placed on these posts after the first exposure is made. This will be necessary as the grid must be on the same level as the pelvis to show the proper magnification of the dots. The central ray is centered to the exact spot of the first exposure when using the lead grid, but when the strip is used the tube must be shifted over the strip.

In the lateral view of the Thom's method the patient is erect. The patient stands before a vertical cassette holder or vertical table in the lateral position. A restraining band can be used to help maintain the position. The patient is centered to the film in a true lateral position. The arms are crossed over the chest. The lead perforated strip is placed close within the crease of the buttocks so that it is included on the film. The central ray is directed horizontally to the film and enters a point two inches posterior to the top of the greater trochanter. This should place it between the anterior surface of the curved sacrum and the greater sciatic notch.

## COLCHER-SUSSMAN METHOD

This technique is one of the new methods used in pelvimetries and is being used in about twenty-five percent of the Air Force clinics today. It is fairly simple to perform. This technique uses a device with a strip of metal with holes drilled every centimeter. It is known as the X-ray Pelvimeter. This strip or rule is mounted on a graduated post so that the rule may be moved up and down as needed. It can be clamped to the table with a "C" clamp for vertical or horizontal lateral views.

The patient lies on the table in the supine position. The knees and hips are flexed with sandbags over the feet to help immobilze the position. The knees are separated. The pelvimeter rule is placed against the gluteal fold at the level of the ischial tuberosity. You can find the tuberosities by palpating the symphysis pubis and aligning the rule to this structure. Then just lower the ruler 10 centimeters and it will be at the level of the ischial tuberosities. The film is placed crosswise and must include the rule of the pelvimeter. The central ray is directed perpendicular over the symphysis pubis. All of the transverse diameters of the pelvis are on the same level as the pelvimeter in this position.

The lateral position may be taken in the erect or recumbent position. The patient assumes the lateral position. The film is centered to include the rule and the symphysis pubis. The pelvimeter is adjusted so that it will fit between the crease of the buttocks. The tube is centered so that the central ray is directed just over the greater trochanter of the femur.

As you can see you need take only two exposures. Both positions are easily

assumed by your patient and all of the information will be recorded in these two views by the rule of the pelvimeter. The doctor will use a chart provided for this technique in figuring out the various diameters from the films. Your job will be to take the films and not in determining the diameter factors. However, you must have accurate positions for the doctor so that he can measure accurately.

Other methods of pelvimetry are performed with the positions that were mentioned earlier. You will undoubtedly encounter many variations in equipment and positioning techniques. Do not regiment your ideas on the way to perform pelvimetries. Learn each new technique as you meet it.

## FOREIGN BODY LOCALIZATION

You will seldom be called upon to locate a foreign body. There will be occasions when you might, however, and you should know some of the techniques of locating them. Of course, in time of war there will be more frequent need for these techniques.

Localization techniques are varied. Foreign bodies in the extremities can be fairly accurately located using right angle views. In the trunk of the body, however, a more extensive type of technique must be performed. The eye requires the use of a special localization technique that is known as the Sweet's method. You will only be given a few of these techniques. These are the more common ones that are used in the Air Force.

### BODIES IN EXTREMITIES

Foreign bodies that are in the extremities of the body can be located by using right angle views. These views may be the posterior-anterior and lateral, anterior-posterior and lateral. At times the point of entry of the foreign body may be marked with a lead marker or a barium paste may be used. Extra care is necessary in taking the films with accurate positions.

### BODIES IN THE TRUNK

Foreign bodies in the chest, abdomen, pelvis or spine can be located using the "Single Triangulation Method". This is a simple technique and requires only a short time to perform. Accuracy is very important in any examination of this type because the purpose is to locate the body for removal in surgery. The technique informs the surgeon how far down the body is into the tissue.

SINGLE TRIANGULATION METHOD. The patient is placed in the prone or supine position on the table. The doctor will fluoroscope the patient and locate the foreign body. He will use a skin pencil to mark the skin of the patient over the spot that shows the foreign body.

When this has been finished, you will place a film under the patient or in the bucky tray and center it to the skin mark. You will center the tube over the mark.

Now you must measure the distance from the target to the skin. Write this down. Also write down the focal-film distance you are using. Expose the film using only half your technique. Shift your tube lengthwise a distance of 6 inches without disturbing patient or the film. Write this down. Make your second exposure using the other half of the technique. The film is then developed.

You now have three things: The TSD, FFD and amount of tube shift. From the film you will measure the distance between the two images of the foreign body that you can see on it. With these four figures'you are going to draw a scaled set of triangles. You will need a sheet of 8-1/2 x 10-1/2 inch paper and a rule. You can make the scale 1/4 inch to 1 inch.

Draw a line that represents the FFD (Line A C).

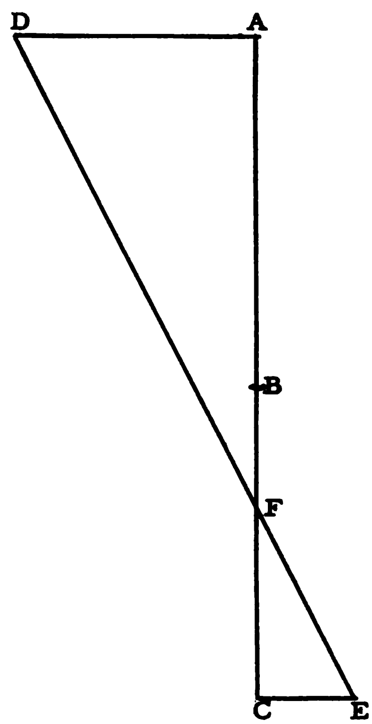
Draw a line that represents the TSD (Line A B).

Draw a line that represents the amount of tube shift (Line A D).

Draw a line that represents the amount of image shift (Line C E).

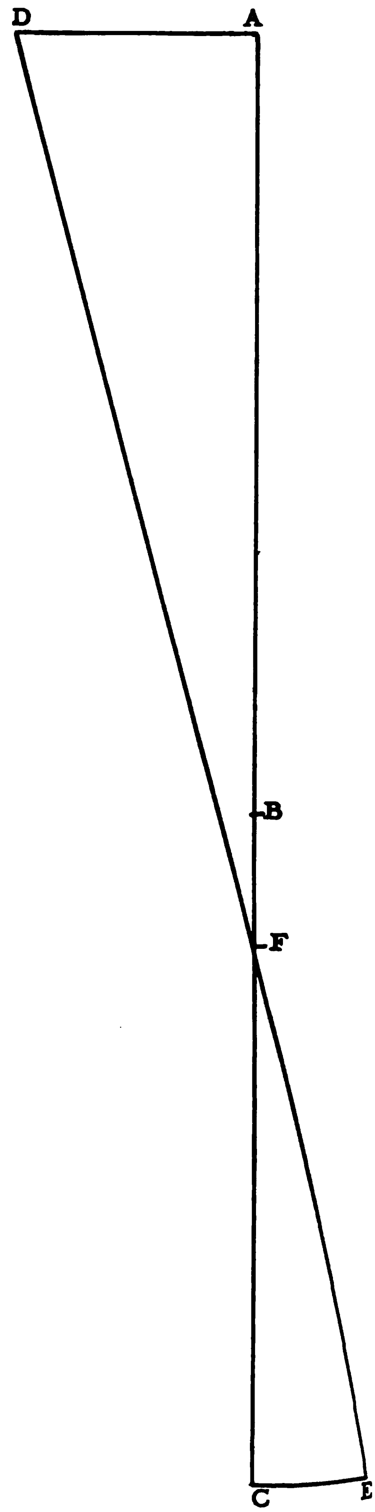
Draw a line from D to E.

The location of Foreign body F is where line D E intersect line A C.




This still doesn't tell you how far beneath the skin the body is. You will next measure the line AF. This is the distance from the focal spot to the foreign body. Next you will measure the line BF. This is the distance from the skin surface to the foreign body. Subtract AB from AF and you have the location of the foreign body.

Let's use an example with figures.




| | | | |
|---|---|---|---|
| Focal-Film Distance | - | 36 inches | AC |
| Target-Skin Distance | - | 20 inches | AB |
| Tube Shift | - | 6 inches | DA |
| Image Shift | - | 3.3 inches | CE |

Scale - 1/4 = 1 inch

| | | |
|---|---|---|
| Line AB | = | 5" |
| Line AC | = | 9" |
| Line AD | = | 1-1/2" |
| Line CE | = | 7/8" |
| Line AF | = | 5-3/4" |
| Line BF | = | 3/4" |

As you can see AC-AB equals line BF or three-fourths of an inch. Each fourth equals one inch. The distance below the skin surface is three inches.

## SWEET'S EYE METHOD

This method is used in the localization of the foreign bodies in the eye. The eye is not adapted for surface marking like the trunk. It needs a special technique. You will need a special device for this examination.

EQUIPMENT. The localizing device is made up of two units, the localizer unit (Figure 10-1) and the head support and film tunnel unit (Figure 10-2).

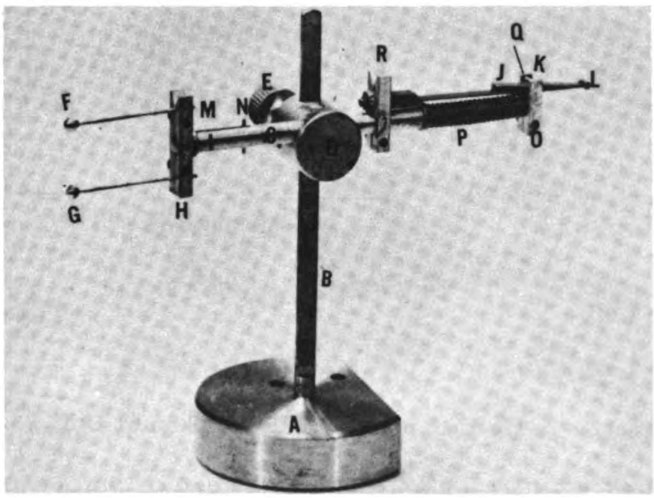



Figure 10-1 Localizer Unit

Localizer Unit

1. Heavy metal base A, serves as support for the unit.

2. A vertical supporting arm B, provides adjustment and fixation of the horizontal supporting Channel C.

3. A supporting bracket D, having a setscrew E, provides for raising and lowering and fixation of the horizontal channel arm C.

4. A metal ball F and metal cone G, spaced 15 millimeters apart, and supported on bracket H which in turn is fixed to rod I which moves within horizontal channel arm C.

5. Spring catch J, having engaged notch K and trigger release L, serves for forward setting of the ball and cone and then releases them to the extent of exactly 1 centimeter as controlled by slot M in the supporting channel arm C and stops N mounted on rod I.

6. Bracket O fixed to rod I serves for support of recoil spring P and catch Q which engages notch K.

7. Sighting notch R, serves for true positioning of the ball F in apposition to the center of the cornea.

Head Support and Film Tunnel Unit

1. A special pedestal tunnel S, having lead protection over its upper, outer thirds so as to provide for exposure of one-half of an 8 x 10 film contained in a cardboard holder and positioned in the sliding tray T.

2. Vertical supporting columns U, to serve to support head clamp V.

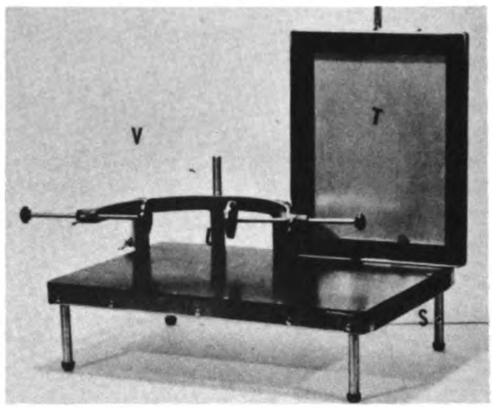



Figure 10-2 Head Support and Film Tunnel Unit

TECHNICAL PROCEDURE. The patient is placed on the X-ray table, lying on the same side as the eye in which a foreign body is thought to be contained. The pedestal tunnel of the headrest is placed beneath the head and the head is positioned so that the region of the eyes is superimposed over the portion of the tunnel which is unprotected by lead. The pneumatic ring may be placed under the head if desired. The supporting head fixation pads are then positioned to the head to fix it in a position wherein the midsagittal plane is parallel to the film.

Place the localizer on stand, ball and cone side nearest the eye. Sighting through notches R, align the metal ball F to center of cornea. The cornea is the center of the pupil diaphragm. Fix set screw E. Engage horizontal rod I by means of the spring catch J, at notch K. Have patient close eyelids and advance localizer unit until the metal ball F presses into the lid to an extent equivalent to the thickness of it. Release trigger L and allow the patient to open the eyelids. After opening the eyelid, instruct the patient to maintain a focus onto an object at a distance and in line with the sighting notches R and the metal ball F. This is important.

Align the focal spot of the tube over metal ball F and cone G. The focal spot, ball, and cone are aligned so the central ray is perpendicular to the film. A focal-film distance of 30 inches is used. The film is placed in the tray T so that one-half of it lies beneath the unprotected part of the tunnel. The film will be beneath the eye and localizer ball and cone. Make a light exposure so that the ball and cone and the foreign body are not burned out. Position the film again for the other half to be exposed. Move your tube 6 inches toward the feet and make a second exposure using the same technique.

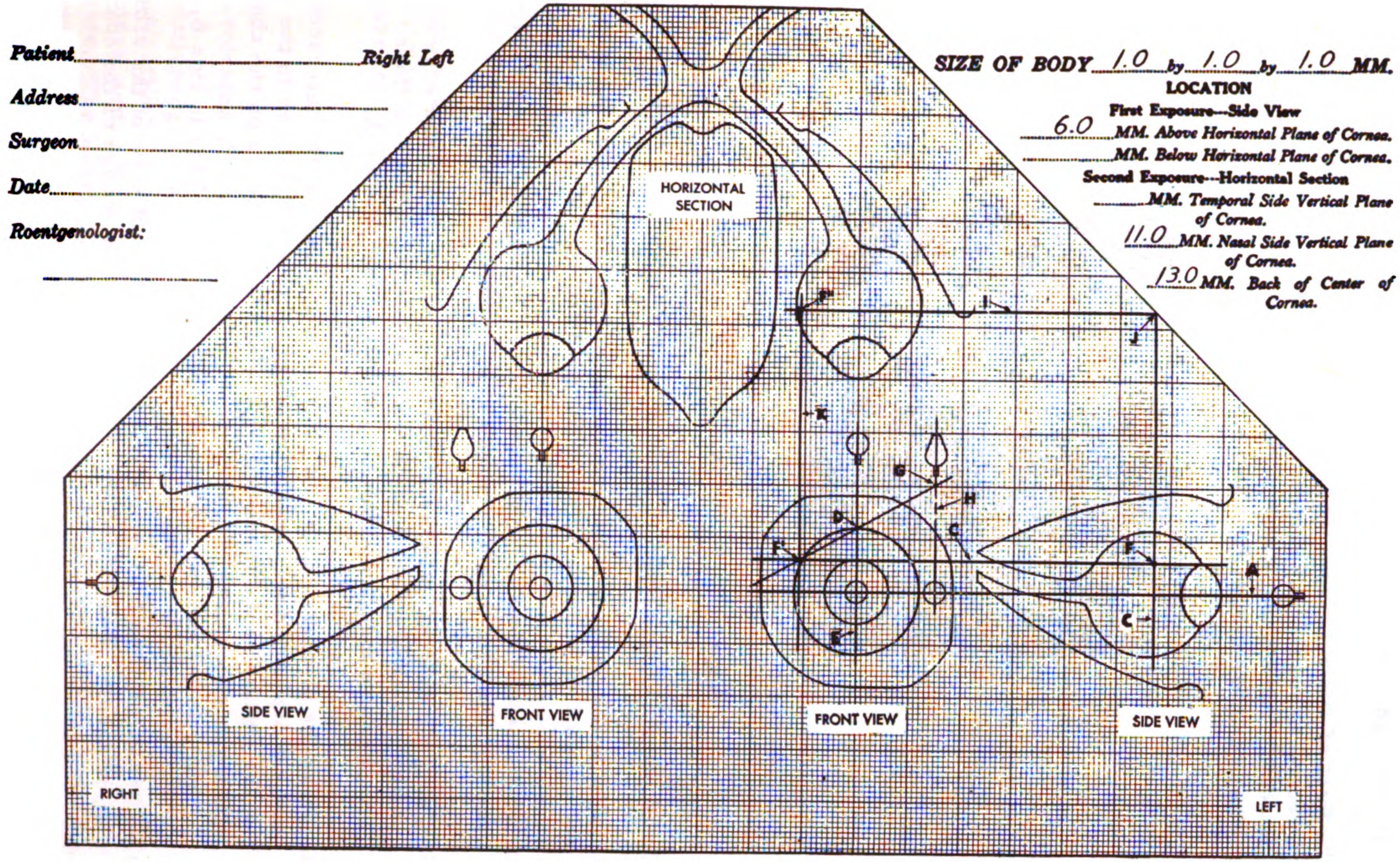



Figure 10-3 Sweet's Eye Method Chart

CALCULATING LOCATION FROM CHART. A special coordinate chart is provided for the examination (Figure 10-3). The film and this chart are used to show location of the foreign body.

On the first of the two exposures, the ball and cone are superimposed (Figure 10-4). The second exposure will show that the ball is projected toward the head farther than the cone. You should see the entire orbit of the patient. Look for the foreign body. There may be more than one and each must be plotted separately.

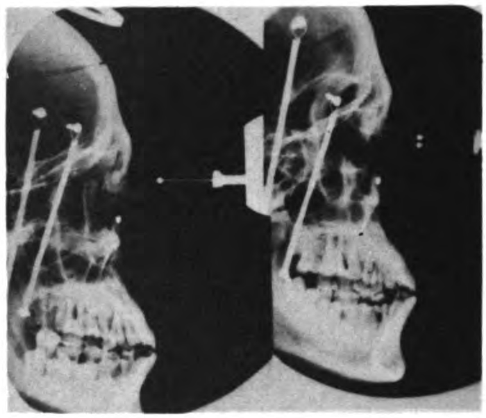


Figure 10-4 Films, Sweet's Eye Method

Charting Technique. Complete these steps using the first exposure:

1. Etch a line on the first exposure of the film through the horizontal axis of the ball and cone. This line is the optic axis of the eye.

2. Etch a second line at right angles to and intersecting the first line through the center of the outline of the foreign body.

3. Using a small pair of dividers, set its points -one to the edge of the indicator ball and the other to the intersection of the two lines. Place this distance onto the chart. This will appear as line A.

4. Using the dividers again, set its points so one is at the intersection of the vertical and horizontal lines on the film and the other to the center of the outline of the foreign body. Place this distance on the chart. This procedure serves to locate the foreign body at F, anterior-posteriorally in relation to the lateral vertical plane. This is line B.

5. Extend line A so that it crosses over to the front view of the orbit on the chart and then extend line B up to the oblique edge of the chart.

6. Extend a line C horizontally from the location of the foreign body F, and make it parallel to line A, across to the front view of the orbit.

With the second exposure, the following steps are completed:

1. Etch one line through the axis of the ball and its supporting arm and another line through the axis of the cone and its supporting arm.

2. Etch a third line at right angles to and intersecting these two lines through the center of the outline of the foreign body.

3. Using the dividers, set its points, one to the center of the outline of the foreign body, the other to the intersection of the etching concerned with the ball. Place this distance onto the chart as shown by point D on line E. If foreign body lies on the same side of the ball axis as does the cone, this distance should be laid off downward from the point of intersection of lines A and E.

4. Again, using the dividers, repeat this procedure with respect to the center of the outline of the foreign body and the intersection of the etching concerning the cone. Place this distance onto the chart in relation to the outline of the cone as shown at point G on line H.

5. Extend a line through points G and D, intersecting line C at F. These distances serve to locate the foreign body at F, laterally, in relation to the front view vertical plane.

6. Extend line I from the intersection of line B and the oblique edge of the chart at J, parallel to line C, so that this line crosses the horizontal outline of the orbit.

7. Extend another line K at right angles to line C, from the point $F^{I}$, so as to intersect line I at point $F^{II}$. These extensions serve to locate the foreign body at $F^{II}$, laterally, in relation to the horizontal plane.

Now, by merely counting the millimeter coordinate spacings, it is possible to render a report as to the location of the foreign body with respect to the central axis of the eyeball and in relation to the side view, front view, and horizontal planes. The findings are recorded in the upper right hand corner of the form.

You must be very careful if you do the charting. Usually the radiologist will do this, but you may in extreme circumstances. Be sure that you plot the right eye. Also be sure that your distances are accurate.

## PHOTOFLUOROGRAPHY

Photofluorographic machines are used to survey a large number of men for chest examinations. These machines incorporate a fluorescent screen, phototimer, and a camera unit. With the camera, the large image can be reduced to a much smaller size. The X-ray beam passes through the patient, activates the screen, the light from the screen is scanned by a phototube which terminates the exposure at the proper moment, and the light passes back through the lens of the camera to the film at the back of the unit. As you can see, this unit uses X-ray, fluoroscopy, photoelectric principles and photography. Its purpose is to reduce the size of the image, cost and time of examination for large numbers of personnel.

## TYPICAL CONSTRUCTION

All photofluorographic machines have a control panel, tube unit, transformer, hood unit that encloses the fluoroscopic screen, a grid, the phototimer, an identification apparatus and the camera unit. The Air Force uses the machines manufactured by five different concerns. Specific operational instructions are furnished with each unit. This section will deal generally with the operation of one of them.

## IDENTIFICATION

Each patient is given a DD 812, on which is entered all of the identification information. This card must be placed in the identification slot of the machine so that it can be photographed onto the patient's film.

## CALIBRATION OF MACHINE, WESTINGHOUSE, 200 MA

The machine is normally calibrated before use. These instructions are usually placed directly on the machine so that you can follow them step by step.

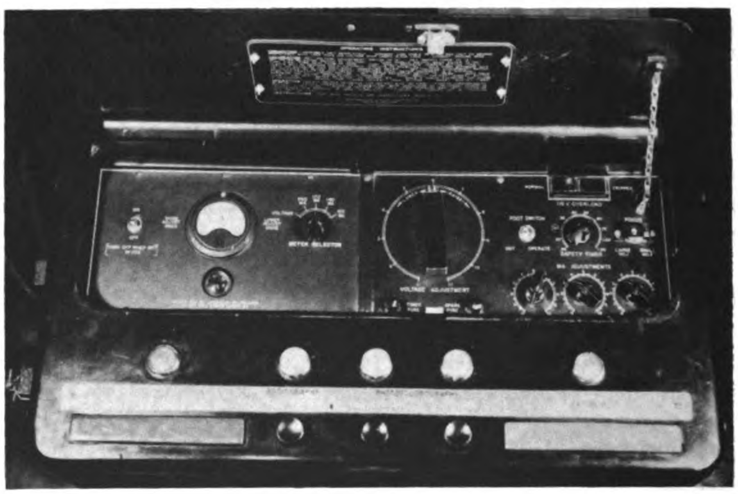


Figure 10-5 Westinghouse 200 MA (PFX), Control Panel

The control panel, Westinghouse, 200 MA, is typical for a photofluorographic machine (Figure 10-5). To turn the machine on you push any of the buttons that you see on the edge of the panel in the center. A light above the button will come on. You will wait at least 30 seconds so that the circuits can come up to proper operating temperature. This wait is very important. Because this machine has an underload metering device, it must be calibrated for proper exposures. After the machine is calibrated, you turn off the meter and use the buttons and exposure bar for ordinary operation.

Using Figure 10-5, follow these steps for the calibration of the unit.

- Turn the voltage adjustment switch (long silver bar in center of unit) to number 6. You will feel definite contacts.

- **Turn the safety timer (small switch to the left of the voltage adjustment switch) to the circled 0.2 second.**

- **Turn the meter selector switch (small switch to the right of the voltage adjustment switch) to the setting "voltage".**

- **Flip the toggle switch to the left of the meter to the "on" position.**

- **Adjust your X-ray tube so that it faces away from the hood section.**

- **Go back to the panel and hold the button labeled "Small Patients" down. Don't punch the button, but hold it down firmly and slowly.**

- **Look to see if the light indicator just below the meter lights up and wait for a period of at least 20 seconds.**

- **Press down on the exposure bar until the needle on the meter indicates that an exposure has been made. Notice the direction that the needle moved. If there is a buzzing sound, after the exposure was made, it will tell you that the machine stopped at 0.2 seconds (on safety timer).**

- **Switch the voltage adjuster, either higher or lower, from your observation of the direction the needle moved on the first exposure. Make exposures and adjust until the needle is steady.**

- **Press the button labeled "Radiology, All Patients".**

- **Turn the meter selector switch from Voltage to 125 MA.**

- **Push the exposure bar and watch the meter needle move. Turn the small switch in the lower right corner labeled "green" either way until the needle is steady.**

- **Return to the "Small Patients" button and press it down firmly. Set the meter selector switch to any MA you want. You only need to calibrate one of the MA's, so you can use any of them.**

- **Make another exposure using the amber MA adjustment switch. Move this switch up or down until the needle is steady.**

- **Press the "Large Patients" button. Turn your meter selector switch to the MA you want. Make another exposure and adjust the red MA until the needle is steady.**

- **Move your meter selector switch to Voltage again and make another voltage calibration to check your settings.**

- **Re-adjust your tube to face the hood. Turn the safety timer to the rating shown on the tube rating chart.**

- **Under the hood of the unit is the control for the density that is regulated by the phototimer. You will need to make some trial exposures to select the right density settings.**

> Do not use a person to calibrate your machine because the exposure times may be varied and this will cause inaccuracy in the operation of the meter.

When you finish with this calibration, the unit is ready to begin operation. Your unit should be calibrated each morning.

## THE CAMERA UNIT

The camera that is part of the unit is located at the back of the hood section. It is generally a Fairchild Fluoro-Record Camera, Type F-212. It uses roll type 70 mm. film and you can take from 300 to 400 pictures on a roll. The camera is connected to the circuit of the machine so that it will roll the film automatically after each exposure. There are two parts to the camera. The "body" holds the lens, motor and operating mechanisms. The "magazine" holds the film, film spools, advance devices, a pressure plate and electrical connections which show that the film is advanced or used up.

INDICATOR LIGHTS. There is a red lamp on the side of the camera unit that blinks or flashes while the leader or trailer of the film is being run through the camera. When this light is off, it will show you the camera is ready. Usually you will have a lamp located somewhere on your control panel or near it so you can see when the film advances. The light will flash three or four times and you know that there is a new frame ready for exposure. More or less flashes will indicate that the film is not moving properly from the magazine. When the film runs out, the machine will not make an exposure.

LOADING CAMERA. Film should be handled in the darkroom under a Wratten II filter if the film you are using is blue-sensitive. If it is green-sensitive, you will handle it without any light at all.

> To take the magazine off the camera unit on the hood, press the latch release on the bottom and lift straight up. (Figure 10-6).
>
> Take the magazine to the darkroom and lay it face down on the loading bench. Unscrew the cover screw at the back and take the lid off.
>
> Open the film can and remove a fresh roll of film. Put the unexposed film in the feed position. The feed position is drawing the film down the underside of the spool so that the emulsion (dull feeling side) is facing the camera lens.
>
> Take about 18 inches of the leader and thread it through the film magazine. When the leader passes through the magazine facing opening, you can push it along with your fingers. Shove the film along between the meter and idle rollers onto the take-up spool. When the film is on the take-up spool, twist the spool several times so the film is fastened tightly to it.
>
> Replace the cover on the magazine so the handle is at the take-up end. You will need to press it down on the tension springs and then screw the cover screw into place.

- The magazine is replaced on the camera. Lift the handle and lower it until the hooks fasten onto the suspension rod on the main camera on the hood of the unit. Snap the lower end of the magazine into the magazine latch at the bottom of the camera unit. Once the magazine unit is loaded and set in the camera unit, the film must be advanced until the emulsion is framed for the first exposure.

- While pressing the film-advance switch, look at the blinking light. It will take about 15 seconds to bring the perforated portion of the leader into position. The light will go out when this perforated section reaches the proper position.

- The light will flash again when the film is ready for exposure. Let the light flash two or three times before you let up on the film-advance switch.

UNLOADING. The operation of unloading the camera is simple.

- Push the film-advance switch from 15 to 20 seconds so that the trailer of the film is wound on the take-up spool. Look at the indicator light and when it stops blinking, the trailer is through the camera.

- Take the magazine off the camera and take it to the darkroom. Follow the procedures for removing cover that you read in the loading section. Lift out the film spool that is loaded and place the empty spool into its position. Be sure to get the square hole of the spool over the square end of the driving shaft.

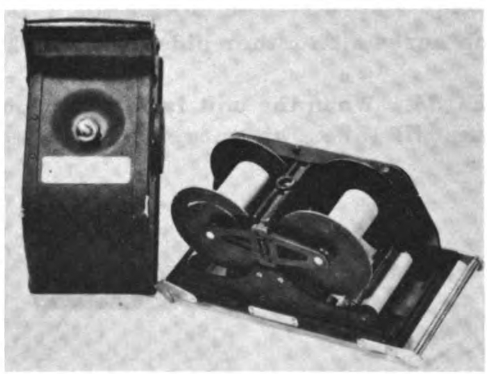


Figure 10-6 Camera Magazine

## DEVELOPING ROLL FILM

The development of this roll film is a relatively simple operation once you have practiced it. The usual difficulties are threading the developing spools in the dark so that the film is wound on them properly. You will need a great deal of patience at first. Keep in mind that you have from 300 to 400 exposures on a roll of 70 mm. film and you cannot afford to ruin it. Take care to do each step of the processing as well as you possibly can.

TANK. There is a specially designed tank that is used to develop roll photofluorographic film (Figure 10-7). It consists of a stainless steel tank, developing film spools, a motor unit to turn the film through the solutions and a rubber hose. The tank is light tight so that when it is loaded and closed the lights in the darkroom can be turned on.

Loading the Tank. You will load the tank as instructed below:

- Unscrew the thumb screws from both ends of the tank. Lift the top up and place it to the side. You will see the film spools.
- Remove the reel lock pin from the shaft of the spools. Put the right hand spool to one side. Remove the film retaining clamp on the spool. Roll about 1 foot of the leader from the camera spool and fasten it to the developing spool with the clamp. Remove the left hand spool. Put the exposed roll of film on the left hand shaft. The square hole on the flange is facing up. Roll the film onto the right developing spool so that the emulsion is facing out toward you.
- After the film is rolled onto the right developing spool, remove the film spool and replace the left developing spool. Put the end of the film into the slot in this spool and place the spool clamp so that the tongue of the clamp goes into the slot with the film.
- Place the plastic spacing washer over the shaft of the loaded spool and then lock the spools again with the reel lock pin.
- Take the film retaining clamp off the spool and put the film into the tank.
- Fasten the thumb screws on either side of the tank.

PROCESSING ROLL FILM. When the unit is loaded, you will proceed with the processing. This processing will take a bit more time than ordinary radiographic film.

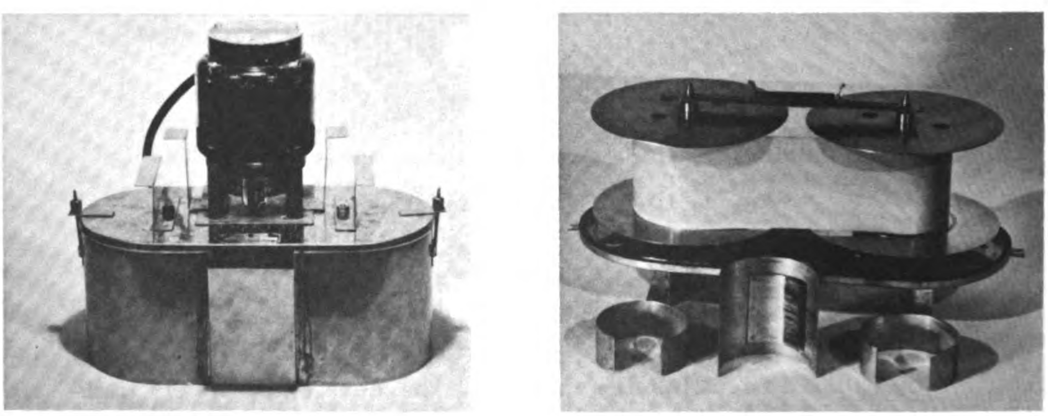


Figure 10-7 Developing Tank

Pre-Wash. Photofluorographic roll film is pre-washed. Pour clear water into the tank. This water should be about 68° F. Turn the handle on the top of the tank and run the film through the water two or three times to make sure that it is wet. Tip the tank up and pour the water out.

Developing. This tank will hold a gallon of developer. The developer should be at 68° F. Pour it into the tank as quickly as possible. Place the motor on the unit over the handle before you do this and plug it in. The motor will turn the film back and forth. The time of development will depend upon the amount of film that you have to develop. Each full roll will contain a hundred feet. You may develop a whole roll or a part of a roll. Check the instructions on each package of the film for the proper developing times as advised by the manufacturer. It is important that the developer you are using be fresh and at the right temperature. If your solution is not up to standard, then don't take a chance - make up some new solution. Remember there are 300 to 400 examinations on your roll.

Fixing. After developing, pour the developer out and then rinse the film with clear water at least two times. You may also use an acid bath. Drain your tank and pour fixer solution into the tank. You will fix the film at least ten minutes.

Washing. When the films are fixed, pour the fixer out. Loosen the thumb screws on the ends of the tank. Put the rubber hose down into the spout of the tank and turn the water on until it pours easily over the top of the tank. Leave the motor on the tank. Wash about 20 minutes.

Drying. There is a special drying unit that is used for photofluorographic roll film. It is a motor driven wheel with heat lamps placed at the bottom. The film is clipped onto the frame and wound around it. The unit is plugged in and the lamps are on. The wheel frame rotates so that the heat is evenly spread. It will take from 30 to 45 minutes to dry the film.

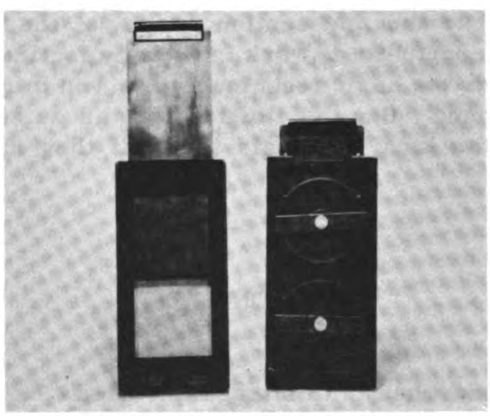


Figure 10-8 Cut Film Holder

CUT FILM

Some photofluorographic units use 4 x 10 inch cut film. All photofluorographic

film has emulsion on one side only, instead of both sides as the regular radiographic film. You will have film holders similar to those that are used by photographers. The camera unit is usually extended into the darkroom where you can load and unload your film. The 4 x 10 size will allow the use of stereoscopic techniques. The film holder is placed in the camera unit and pushed down. The first exposure is made. The technician pushes his stereo button and the film moves up for the second exposure. The technician must then remove the holder from the camera, replace his holder shutter, turn the film around and reinsert it into the camera for the next patient. The use of cut film is a little slower than the roll film. More Air Force clinics are turning to roll film now.

A handbook is available from the government printing office on all the various types of photofluorographic machines. It is a Public Health Service publication and gives specific operation instructions for all units.

HANDBOOK FOR PHOTOFLUOROGRAPHIC OPERATORS, United States Government Printing Office, Washington, D.C., 1950, Reprinted 1951, Public Health Service Publication No. 18.

Order from:

Superintendent of Documents
U. S. Government Printing Office
Washington 25, D. C. 45 cents

You have just completed a rather large section of special procedures and techniques. These procedures will have many variations, but if you learn the basic steps, the others will come easy. It will take time and experience in doing these examinations well. The important thing to remember is that until you are absolutely sure of what you are doing, you must ask questions. Do not attempt to bluff your way through. Your work will be measured on what you can do and not what you say.

The next chapter is your therapy section. Many of the technicians in the Air Force will be provided an opportunity to work in therapy sections in the future. This chapter will provide you with the basic techniques that you might use. It will familiarize you with the equipment. Use the illustrations as an aid while you read the material. Check some of the local hospitals to see if they have therapy units and visit them.

## QUESTIONS

1. What is stereoscopy and when is this technique used?

2. What is meant by shift? What factors must you know to determine the amount of tube shift you need?

3. What are predominant lines?

4. Explain the procedure you would use in stereoing a skull.

5. Explain the procedure you would use in stereoing a chest.

6. Describe the procedure used in preparing the films for viewing.

7. Why are pelvimetries performed?

8. What are four of the diameters the radiologist wants to measure in a pelvimetry?

9. What are the basic positions used in pelvimetry?

10. Explain the Thom's method of pelvimetry.

11. Explain the Colcher-Sussman method of pelvimetry.

12. What is meant by "foreign body localization"?

13. How are foreign bodies localized in the extremities?

14. What is the "single triangulation method" of localizing a foreign body? Explain procedure.

15. What is Sweet's method? Describe Sweet's method.

16. What is photofluorography?

17. What equipment is necessary for a photofluorographic unit?

18. How would you calibrate <u>your</u> photofluorographic machine?

19. Explain how you would develop photofluorographic film in the Fairchild-Smith tank.

20. How is cut film used in photofluorographic procedures?

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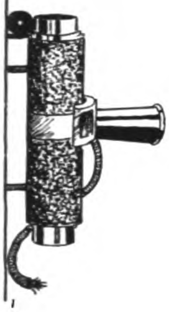


# CHAPTER 11

## RADIATION THERAPY

Radiation therapy - to many technicians this procedure is a highly complicated and mysterious section of their field. This chapter is to be devoted to familiarizing you with the equipment, procedure and records that are maintained by the therapy section of an X-ray clinic. Because of the amount of time that is necessary for these procedures, and the differences in the techniques, a technician doing therapy work is usually separated from the diagnostic section. In many instances in civilian life, a technician works only with therapy and has no knowledge of the diagnostic procedures. In the Air Force, a five or seven-level skill requires knowledge of therapy procedures, as well as diagnostic techniques.

A technician that is fortunate to be assigned to a station with a therapy section will find his work highly interesting. Therapy requires very close working relations with the radiologist. This enables you to expand your knowledge of radiation, its effects on human tissue and the materials and equipment involved in producing radiation. Knowledge of therapy provides the technician with a greater feeling of professionalism. Being realistic, however, few of the technicians in the Air Force at the present time will have the opportunity to work with radiation therapy. But in the future, possibly the next five to ten years, the field of radiation therapy will be greatly expanded. You should prepare for the future. In view of the above statement, you may wonder why you should study therapy if you may never work with it. The answer to this is the need for preparing yourself for the future possibilities of being assigned to stations having therapy units, and the increase in the number of therapy centers that will come in the next few years. Whether it can be realized at this point or not, you must continually keep storing up knowledge for future use. Although it will take some actual experience in a therapy section to become thoroughly familiar with the duties involved, you will glean, from this chapter, some of the background knowledge which will make those duties more meaningful and easier to perform. You can learn therapy just like you have learned or are learning the diagnostic procedures.

The treatment of disease with radiation is presently divided between two techniques. These techniques are the X-ray radiations provided by X-ray machines and those radiations provided by radioactive materials. Radium, of course, is the most familiar radioactive substance. The advent of the other radioactive materials within the past ten to fifteen years is throwing continuous new light on treatment of various diseases and body functions.

The material presented in this chapter is basic. Attempts will be made to give you information which will help you better understand what is happening, but you must realize that in therapy you will be required to research on your own for a great deal of your information.

## YOUR THERAPY SECTION

Your duties in X-ray therapy are to assist the doctor as requested, operate the controls of the equipment as directed by the doctor, and maintain the therapy records. You will be under the direct supervision of the radiologist at all times.

Let's begin your first day in a typical therapy section. The section will be composed of a reception, deep therapy, and superficial therapy areas and a doctor's office.

The time is 0730 and as you look up, a technician enters the section and sits down at the reception desk. Before him on the table is a standard bound ledger. The ledger has a title written on it. The title reads, "Therapy Appointment Schedule". The technician opens the ledger, glances at its contents and begins to prepare for the day's work ahead. As he begins to get up, he sees you in the doorway and says, "Hello, what can I do for you?"

"I'm here to learn a little about how the therapy section works", you say, "and I'm to see Sgt. Blank."

"Fine. I'm Sgt. Blank and I'm glad to have you with us. You will have a great deal to learn, but I will try to help you all I can. I will show you around so you can see some of the equipment we have here."

"I'm ready to start," you answer.

Waving an all encompassing hand, Sgt. Blank begins to explain the therapy section to you. "This is a model section for a therapy unit, but you will probably see a wide variation from this in other clinics throughout the Air Force. This room is reserved for the doctor so he can examine the patients as they come to the clinic for treatment. The large room is the deep therapy room. The smaller room is the superficial therapy room. And, of course, you are now in our reception area."

"I think it would be better", he continues, "if you learned what is done in each area and the equipment we have in them before we get too far along. The reception area is really the beginning so we will begin here."

### RECEPTION DUTIES

"When a new patient comes to this clinic, he will bring two copies of a form known as the SF 513, Consultation Sheet. (Figure 11-1). This request will be reviewed by the doctor and he will examine the patient. If the doctor feels that radiation therapy will benefit the patient, he will tell you to make an appointment for treatments."

Standard Form 513
Rev. Feb. 1961
Promulgated
By Bureau of the Budget
Circular A-32

| CLINICAL RECORD | CONSULTATION SHEET |
|---|---|

**REQUEST**

| TO: | FROM: (Requesting ward, unit, or activity) | DATE OF REQUEST |
|---|---|---|
| Dr. E.R. Green | Ward 1 | 5 Jul 57 |

REASON FOR REQUEST (Complaints and findings)

Air evacuated from Keesler AFB, Mississippi for deep x-ray therapy.

PROVISIONAL DIAGNOSIS

Teratoma, malignant testis, right, with abdominal metastases

| DOCTOR'S SIGNATURE | APPROVED | PLACE OF CONSULTATION ☐ BEDSIDE ☐ ON CALL | ☐ ROUTINE ☐ EMERGENCY |
|---|---|---|---|

**CONSULTATION REPORT**

(Continued on reverse side)

| SIGNATURE AND TITLE | DATE | IDENTIFICATION NO. | ORGANIZATION |
|---|---|---|---|
| | 5 Jul 57 | AF 0000111 | 5705th AE Gp |

| PATIENT'S LAST NAME—FIRST NAME—MIDDLE NAME | REGISTER NO. | WARD NO. |
|---|---|---|
| Able, Ima Gonabe A/2c | 119058 | 1 |

3810th USAF Hosp. Maxwell AFB, Alabama
(NAME OF HOSPITAL OR OTHER MEDICAL FACILITY)

CONSULTATION SHEET
Standard Form 513

U. S. GOVERNMENT PRINTING OFFICE 16—56110-3

Figure 11-1 Consultation Sheet, SF 513

THERAPY LEDGER. At this moment, a patient comes into the therapy clinic. Sgt. Blank looks up and greets the patient. Asking the patient to have a seat, while he prepares for the treatment, he turns again to you and says, "This will help you in seeing how we fill out this ledger. This patient was given an appointment for this morning at 0745. This is his first visit. On the first visit for treatment, we give him a case number out of the ledger here. In this ledger we put his case number, name, rank, whether he is an outpatient or a hospital patient, and whether he is to receive deep, superficial or radium treatment. We will enter this same information in this ledger each time he comes to us for treatment. We also make out a 3 x 5 index card for him."

INDEX CARDS. You watch as he makes out this index card. He types the case number, name, rank, service number, organization, date and disease. (Figure 11-2, Index Card).

"If this were a civilian or a dependent," he says as he types, "we would place the status of his eligibility for treatment, such as dependent of sergeant so and so, and his phone and street address for reference purposes.

CASE #716

Able, Ima Gonabe, A/2c    AF 0000111
5705th ABGp
5 July 57

Teratoma with metastisis, right testis

Figure 11-2 Index Card

V-C-37-Z    EMBRYONAL CARCINOMA

1. John D. Green 1954

2. Ima Gonabe Able 1957

Figure 11-3 Pathology File Card

"In our clinic we also make out two other 3 x 5 cards. These cards are used for our pathology file (Figure 11-3). This pathology file is kept in each section of the hospital, if your hospital is accredited with the Joint Board of Accreditation. The file must be cross-indexed as to type of disease and the part affected. The illustration of the classifications you see is only one of a variety used in Air Force clinics. You see on the first index card that we have the disease entered. From the classification chart you will be told that it is a Neoplasm. This is Number V. The "C" will show that it is malignant. The number, 37, tells you the part that is involved - the testis. And at the bottom of the chart you will see the "Z", which shows that it is a proven diagnosis. On one of your index cards you will place this code, as on this card: V-C-37-Z, Teratoma (Embryonal Carcinoma), a neoplasm, malignant, of the testis and a proven diagnosis. The cross-index is made with the other card. This card will be made to show the part as the first number: 37-V-C-Z. This file will be used in studying the various types of diseases and the parts where these diseases occur. You will also notice that there are a number of names indicated on each card. Each time you have a case of the same identical classification you will put it on that card. In this manner you can see the frequency of this disease and the doctors can describe the effect of their treatment on these diseases. If you will read some medical literature you will see that they quote so many people treated for this disease,

78 cured, 10 improved, and 2 no results, etc. These files help in the research and study of disease and effect of treatment."

## PATIENT RECORDS

"Now, the patient will be seen by the radiologist. When he comes out, the radiologist will tell me the information I will need to start the patient's treatment. We will weigh the patient first. Then we will fill out forms for examinations that are done before we start the treatment. We store all of the necessary forms in that file cabinet over there. Would you go over and get me one of each kind you see, please?"

"Do you see how they are filed?", he asks you. "Each form number is filed in an individual manila folder."

When you open the file drawer or storage cabinet you will see a number of forms. Labeled on each folder will be the title and form number. These forms are standard medical forms, obtained from medical supply. You will establish a "stock level" of the forms listed below:

| | |
|---|---|
| SF 514a | Urinalysis |
| SF 514b | Hematology |
| SF 514d | Blood Chemistry |
| SF 514m | Miscellaneous Test or Examination |
| SF 509 | Doctor's Progress Notes |
| SF 513 | Consultation Sheet |
| SF 514 | Laboratory Report |
| SF 519 | Radiographic Report |
| SF 519a | Radiographic Report (Request Form) |
| SF 524 | Roentgen Therapy |
| SF 525 | Roentgen Therapy Summary |
| SF 526 | Radium Therapy |
| SF 502 | Narrative Summary |

"That's a good number of forms, isn't it"? he asks you. And you, of course, are nodding your head in the affirmative.

"If you will bring those forms back to the desk, we will continue. With so many forms we will need to have something to put them in. This manila envelope is the one we use. We will write this patient's case number, name, rank and the date on it."

Sgt. Blank tells the patient that the doctor is ready to see him and directs him into the office and introduces the patient to the doctor. Returning to the desk, he says, "We'll be ready to complete our preparations for this patient as soon as the doctor finishes with his examination. While we wait, I'll go over what we have done to this point. You have seen how I have received the patient. He has come in for treatment and I checked my appointment book for his name. All the necessary information is entered in the book and a case number assigned to him. An index card was prepared and two index cards were made for the pathology file. You have gotten all of the necessary forms out of the file cabinet and you have seen that a manila file envelope has been prepared. When the doctor was ready for the patient, I took him into the office and introduced him to the doctor. The patient, when he came for his first appointment, brought with him two copies of SF 513, Consultation Report. The original copy of SF 513 will be returned to the requesting doctor after the radiologist describes the probable course of action he will take in treating the patient. The duplicate copy will be filed in the patient's file, an envelope, as a record of the therapy treatment he is going to receive."

## ASSISTING THE DOCTOR

As Sgt. Blank finishes this summary, the door to the doctor's office opens and the doctor and the patient come out.

"Come along with us now," says Sgt. Blank, "and you can see what goes on in the treatment room."

In the room you watch Sgt. Blank and the doctor closely. The sergeant goes to a cabinet and gets a solution of "gentian violet", cotton swabs on sticks and a centimeter ruler which is made of transparent plastic. The doctor directs the patient to lie down on the couch you see near the machine. The doctor takes the items from Sgt. Blank and you watch as he begins to mark out areas on the body of the patient. You see him mark out an area on the abdomen in the front and one on the back, one on the right inguinal area and areas over the right side of the chest, both in front and in back. He takes the ruler and measures each of the areas that he has marked off. When this is done, he tells the patient to lie comfortably for a bit, while he and the sergeant make other preparations. He motions to you to come as they begin to leave the room.

"You are fortunate on this case," the doctor says to you. "We are going to use all of the various forms on this patient. Usually, they are not all used at once."

Turning to the sergeant, the doctor tells him to get the forms out that you had begun to prepare before the patient came into the clinic.

## FILLING OUT FORMS

"Sergeant," the doctor says to Blank, "I want to have a urinalysis, hematology and blood chemistry after the treatment today. Also make up my doctor's progress notes sheet. I'll be back in a minute to give you what we need for the SF 524."

"Yes, doctor," Blank says and begins to get the laboratory requests ready.

"The yellow slip," he tells you, "is the SF 514a, Urinalysis. You will fill this out like this model form that I have here. You will put down on the slip or check those things that the doctor wants. If he wants a specific examination, other than the routine, he will tell you. The same is true for the other forms, Hemotology, SF 514b and Blood Chemistry, SF 514d. If there are tests he wants of the tissue cells or some other type of examination, he will tell you and you will put this request on SF 514m, Miscellaneous Test or Examination."

After filling out the laboratory forms, Sgt. Blank begins to fill out a SF 519A, Radiographic Reports.

"Why are you doing that?" you ask Blank.

"This is usually a routine thing for us to do when the patient comes for his first visit. We take a PA and a left lateral chest of each patient and, of course, we weigh him. We also prepare a SF 514, Laboratory Reports and a SF 519, Radiographic Reports so we can file each of the patient's laboratory and radiographic reports. A model form will be found on pages 11-31 and 11-32. Study these over so you see how they are filled out. Every time the patient has some work done, these reports are placed on these two forms and become part of the patient's Clinical Record.

"The progress notes the doctor mentioned is this form, SF 509, Doctor's Progress Notes. During the course of the patient's treatment, the doctor will make notes on the progress of the treatment. See Model form on page 11-33.

"Before the doctor gets back, let's see what has happened since he and the patient came out of the doctor's office. You watched us take some of that purple dye, gentian violet solution, and mark off various areas on the chest, abdomen and right inguinal area. These areas were measured and then we came out here. I was told to prepare a SF 514a, Urinalysis, SF 514b, Hemotology and SF 514d, Blood Chemistry. I also told you that when other types of examinations are required of the laboratory. we used SF 514m, Miscellaneous Test or Examination. I filled out a SF 519a, Radiographic Reports, for a PA and left lateral chest, which you asked me about. We prepared SF 514 and SF 519 so we could file our laboratory and radiographic reports. And I have prepared for the doctor SF 509, Doctor's Progress Notes, which he will use during the course of treatment. When the doctor comes back you will see how we fill out the SF 524, Roentgen Therapy. Here he comes now."

## TREATMENT INSTRUCTIONS

"Here we go again," the doctor says, and looking at you, "This may sound like Greek to you now, but as the sergeant gets further along you will see that it will make sense."

Turning again to the sergeant, the doctor begins, "This patient has Teratoma with metastasis, right testis. I am going to use 250 KVP, Thoraeus II filter, 70 cm TSD and 30 MA. I want to give the anterior abdominal portal, 2200 r; posterior abdomen, 2100 r; anterior chest portal, 2900 r; posterior chest, 2900 r and the right inguinal region, 2200 r. I want to alternate between anterior and posterior portals daily. We will give 200 r per day to the abdominal portal and inguinal area and 300 r to the chest portals. The abdominal portals will measure 10 x 30 cm, the right inguinal portal, 6 x 10 cm and the chest portals, 5 x 5 cm."

Taking the SF 524, Roentgen Therapy form, the sergeant begins to fill it out. Looking over his shoulder, you watch as he writes.

Standard Form 524
Revised October 1953
Promulgated by
Bureau of the Budget
Circular A-32 (Rev.)

| CLINICAL RECORD | ROENTGEN THERAPY | | | | |
|---|---|---|---|---|---|
| DIAGNOSIS | | SEX | RACE | AGE | DATE OF REQUEST |
| Teratoma with metastasis, right testis | | M | W | 24 | 5 Jul 57 |

He then enters the physical and time factors that the doctor stated.

| PHYSICAL FACTORS | | | | | | | | | | TIME FACTORS | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TECH NO. | X-RAY APPARATUS | KV | ADDED FILTER mm. | | | | HVL mm. | MA | TSD cm. | r/MIN (AIR) | NO. FIELDS DAILY | INTERVALS | SIG. (Init.) |
| | | | | SN | CU | AL | | | | | | | |
| 1 | 250 Maxitron | 250 | THI | | | | | 30 | 70 | | 3 | QD(Daily) | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |

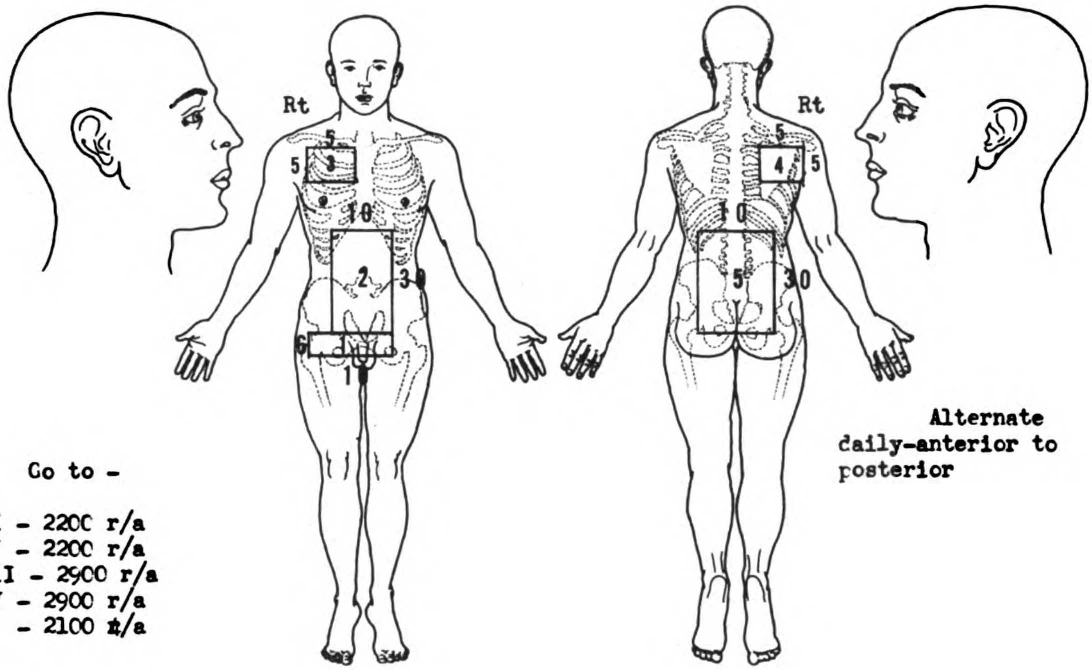
After that the exposure factors were included on the form.

| EXPOSURE FACTORS | | | | DOSE | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| SKIN AREA | FIELD SIZE | ANGLE | DAILY r (AIR) | NO. EXP. | r TO SKIN ($D_o$) | | DIST. SKIN TUMOR | % DEPTH DOSE | TUMOR DOSE ($D_o$) | |
| | | | | | DAILY | TOTAL | | | PER EXP. | PER FIELD |
| Abdomen AF & FA | 10x30 | | 200 | 1 | 200 | | | | | |
| Rt. Inguinal | 6x10 | | 200 | 1 | 200 | | | | | |
| Rt. Chest AF & FA | 5 x 5 | | 300 | 1 | 300 | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | TOTAL TUMOR DOSE ($D_o$) IN | | | | DAYS= | | r |

The next portion of the form is very important. It provides a complete picture of the treatment area. The diagramming should be drawn clear and carefully. There are times when the technician completes this section. The radiologist then checks it for accuracy of measurements and for instructions. Frequently there are necessary changes in the technique such as adding new treatment areas or angulating the beam. All of the additions are placed on the diagram.

The body outlines presented on the form allow the radiologist to show most any surface being treated. The two head views can be used for right and left side ports.

In cases where radium implants are used, such as cancer in female genital organs, an additional diagram is used. This diagram outlines the location of each implant and shows the pattern of the placement. Certain clinics may use local forms for various areas of the body, such as breasts, and include them in the patient's file. All treatment data are included on the form in the same manner as that found on the X-ray treatment diagram. If any form becomes crowded to a point of possible error, it should be reaccomplished. Check the original form closely against the new one to be certain the new form is accurate.




Alternate daily-anterior to posterior

Go to -

I - 2200 r/a
II - 2200 r/a
III - 2900 r/a
IV - 2900 r/a
V - 2100 r/a

At the bottom of the form the sergeant then enters the identification of the patient and the doctor signs the form.

| SIGNATURE OF PHYSICIAN | DATE | IDENTIFICATION NO. | ORGANIZATION |
|---|---|---|---|
| E.R. Green, CAPT. USAF (MC) | 5 Jul 57 | AF 0000111 | 5705th AB Gp |

| PATIENT'S LAST NAME—FIRST NAME—MIDDLE NAME | REGISTER NO. | WARD NO. |
|---|---|---|
| Able, Ima Gonabe | 119058 | 1 |

Case # 715

3810th USAF Hosp., Maxwell AFB, Alabama
(NAME OF HOSPITAL OR OTHER MEDICAL FACILITY)

ROENTGEN THERAPY
Standard Form 524

You notice that the form is still not complete and you ask Sgt. Blank what is done to the other spaces.

"These will be filled in later. You need some more information before these will make sense to you. At least, now, we have the instructions on what to do. Let's find out how we carry out these instructions and then return to the form so we can complete it. There are a number of things for us to do. We have to position and mask the patient, set the machine for distance, get the proper filter in the machine, figure the amount of time we will need to get 300 and 200 roentgens, warm up our machine, check the controls, etc. When these things are explained to you, I'm sure that you will understand more fully what you do in radiation therapy and how the form is completed. I want to show you, now, the equipment we are going to use."

## 250 KVP MAXITRON - DEEP THERAPY UNIT

"This is the General Electric 250 KVP Maxitron. This is the machine used in

Air Force therapy clinics. It is a deep therapy machine. Deep therapy uses kilovolt ranges from 180 to 250 KVP. It is used for deep internal tumors in the body. With accessory devices, it can be used in body cavities such as the mouth or vaginal space."

"It looks pretty big to move easily," you say.

"Yes, it looks that way, but it is quite flexible as you will see later," he answers. "But, now, I will try to show you the machine. After that I will show you the other pieces of equipment we will use in setting up this patient's treatment and then show you how we position and mask the patient."

"The machine is made in three parts. The tube unit that you see in the room is part of the power unit. Part of this power unit is outside of the therapy room, while the transformer and tube section are in the part you see here. The other part of the unit is the control panel section. I will show you how to operate the control panel first."

CONTROL PANEL 250 KVP MAXITRON. "One of the first things is to learn how to control your machine. You notice that the machine may be set on a shelf or desk. This machine must be warmed up before you can give a treatment with it. This warming up period is used to check your various lights and dials. In reality, the warm up is used to decrease, to operating level, the resistence in the various circuits. Notice that this control panel has some things that are similar to those of the diagnostic machine. These are the line switch, KVP selector, KV meter, MA meter, MA selector and timer. There are a few things that are not familiar to you. The lights at the top, for instance - doors, water, shutter closed, shutter open, gas and focus - are new to you. Also, on the left, next to the KVP meter, is a new addition. This is the filter indicator. In the center of the panel is a Victoreen Integron IV. This device is used for direct readings of the number of "r" that are produced while the X-ray is on."

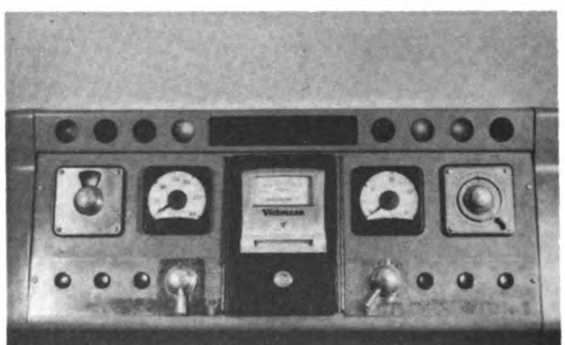


Figure 11-4 Control Panel

Warm Up. "Now that you have given a first glance at the control, let's turn it on for the warm-up. Usually this machine is warmed up the first thing in the morning. This way your machine is ready for treatments when your patients arrive.

"The first thing you do is turn on your incoming line switch. When this is done, you are ready for the control panel itself. I will point out each step to you, but you

will see that there are printed directions right above the panel for you to follow. These directions will usually be over any panel that you operate. Let me caution you to be sure and follow these directions, step for step, and always use your chart to insure that you have followed each step. Follow me through each step.

1. Close the wall line switch. This brings current into your panel.

2. Depress the button ON where you see the word LINE. When this button is pressed, a number of things happen. Some of the lights on top of the panel come on. You will see Line, Shutter Closed, Gas, and Focus light up green. If the doors to the room are closed, the light marked DOOR will turn on also. Now these lights tell you things.

- Line - The light indicates that current is being applied to the unit. This current begins to apply power to your autotransformer.

- Doors - The door to your room has a contact switch built into the frame, so that when the door is closed, the light will show this on the panel. If this door should be accidently opened, during treatments, the light will go out and the machine will automatically shut off. Also, the door light must be on before the machine will begin treatment. It is a safety device.

- Water - This machine is water-cooled. When the light is on, it indicates that the cooling system for the tube is operating properly. This light is on only when X-rays are being produced. This water comes from outside your room into the tube. The water system has a certain flow through it at all times. If the flow of water is not correct, the unit will automatically cut off the exposure. The light indicating water will be out. There is a great deal of heat produced in a therapy tube and water helps disperse this heat.

- Shutter - Closed - There is a system of shutters in this machine that open up to allow the X-ray beam to escape the tube during the treatment. During this warm up period the tube will be producing X-rays, but you should not have them escaping until you want them to. This light should be ON unless you have pushed the SHUTTERS OPEN button.

- Shutter - Open - This light should not be on when the Line ON button has been pushed. When this light is ON it will be red and X-rays will be escaping from the tube.

- Gas - The high voltage system is insulated with sulphur-hexafluoride gas ($SF_6$) instead of oil as you will find in some of your diagnostic machines. If the gas is at the correct pressure, the light will be on. There is a pressure gauge on the side of the transformer in the treatment room.

- Focus - The light will indicate that the focusing coil is energized and that the filament of the tube is heated.

- X-ray - When this is lit you know that X-rays are being produced. If the SHUTTERS OPEN light is on, it will mean that these X-rays are getting out of the tube. With the SHUTTERS OPEN light out, the rays are not escaping the tube.

3. Check each one of these pilot lights. This is the third step and an important one. The lights should be in the following condition at this point in the warm-up.

| LIGHT | OPERATING CONDITION |
| --- | --- |
| LINE | ON |
| DOOR | OFF (Unless door is closed) |
| WATER | OFF |
| SHUTTER CLOSED | ON |
| SHUTTER OPEN | OFF |
| GAS | ON |
| FOCUS | ON |
| X-RAY | OFF |

4. You now have to wait five minutes. Check your watch. To this point, you have really done only three things - turned on the line switch, pushed the LINE ON button and checked the pilot lamps.

5. The next step, while you are waiting, is go get everyone out of the treatment room.

6. After evacuation, close the treatment room door.

7. When five minutes are up, set the milliampere switch to the letter marked A.

8. Once the milliampere switch is set, you set the timer for five minutes. This timer has minutes and seconds on it. The knob in the center of the timer is turned clockwise to five. There is a little black needle which you use to set the seconds when you need them.

9. You next set the filter indicator on the left side of the machine until it lights. There may or may not be a filter in the tube. Turn the knob until you see a light.

10. Go back to the timer and turn the little switch in the lower right hand corner to ON.

11. Next push the X-ray ON button. Hold this button in till the light indicating X-ray is on. The milliampere needle will rise to ten on the meter.

12. Turn the kilovolt selector clockwise to 150 KVP. This selector will not click as in the diagnostic machines. It is a spring type selector, so as you turn it, you must use care until your KV needle rests on the figure you want. Watch it for a moment to see that it stays where you put it. It may wander up or down a bit.

13. After the kilovoltage is on 150 KVP, hold the SHUTTER OPEN button in until the red SHUTTER OPEN light comes on. Be sure that this light is on and that the SHUTTER CLOSED light is off before you release the button. All the lights will be on except the SHUTTER CLOSED. All the lights will be green except the SHUTTER OPEN light. The machine will be releasing X-rays outside the tube. The timer will begin to turn.

14. During the five minutes, you will gradually raise the kilovoltage and milliamperage until 250 KVP at 30 MA is read on the two meters. This is usually done in the following manner:

- Each minute raise the KV in steps of 25 KV and at the same time turn the MA switch to B, C, D, E, etc.

  At 0 to 1 minute turn to 150 KVP - 10 MA - Position A

  At 1 minute turn to 175 KVP - 15 MA - Position B

  At 2 minutes turn to 200 KVP - 20 MA - Position C

  At 3 minutes turn to 225 KVP - 25 MA - Position D

  At 4 minutes turn to 250 KVP - 30 MA - Position E

15. After five minutes, the timer will click, the X-ray will go off. Lights marked WATER, SHUTTER OPEN, and X-RAY will go off. The SHUTTER CLOSED light will come on. LEAVE THE UNIT ENERGIZED. Do not push the line OFF button of the main line switch on the wall. This unit can be kept on all day. Each time it is shut off it will be necessary to warm it up again. By warming it up the first thing in the morning, it will be ready for all the scheduled treatments throughout the day. This is different from your regular diagnostic machines and you must keep it mind."

"Wow!" you say. "I don't thing I'll ever be able to remember all of that."

"Well, yes, it does seem like a great deal to remember," says Blank. "However, keep in mind that it takes experience and actual practice to do it and understand what is happening. But, remember, also, that the directions are available with every unit, that they are posted near your panel and that they include only the directions and not the explanations that I have given you.

"Some trainees don't have these machines, so they could learn this better if they would use the illustration of the control panel, read the directions and use their imaginations in actually operating this unit. For instance, if I spoke of lights, they could turn back to the illustration and imagine they see those lights turn green or go off."

"Yes, I suppose that would be a help if they really wanted to learn it," you answer.

"Okay, now that you have become partially familiar with the control panel, I want to show you how to work the other part of the unit - the tube part. While we're in the treatment room I'll show you how to operate the patient's table, explain filters, distance calculators, masking, the tube localizer diaphragm and cones. When we finish this, we will go back to the control panel and set it up for actual operation for treatment. After that we must get back to our forms. I am giving you this type of training because you will see how the information and tasks actually fit into your working day."

THE TABLE. "The table used for positioning the patient is very flexible. This is necessary because there are countless times that you will need to make fine adjustments to get your fields. With this table you can make these adjustments and not have to move the tube.

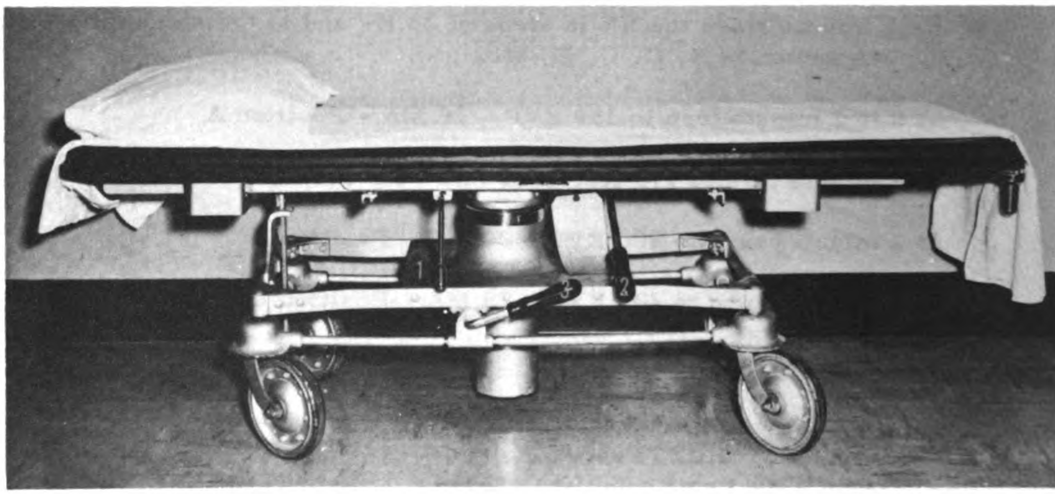


Figure 11-5 The Table

"Where the flexibility of your tube leaves off - your table takes over. You will notice that there are three levers on the underside of the top. Number one is used to loosen the table top from the chassis of the table. The top won't come off, but it will move from side to side with the wheels of the table locked in one position. Number two is a lever used to pump the table up. You notice that the table has a hydraulic tank. If the lever is brought all the way up the table will drop down. This works on the same principle as the barber's chair. Number three is used to lock the wheels of the table. You do not want your patient to move during the treatment. Once he is positioned the table must be locked in position so that it hasn't the possibility of moving. This lever is pushed counterclockwise to lock the wheels and is pulled up to release them."

THE TUBE UNIT. "The tube unit is not as formidable as it looks (Figure 11-6). It can be easily angled or rotated either side to side or in and out. Numbers one and two show the angle indicators. Number three is a chromium rod that can be pulled out or inserted thru its opening and is used for leverage in moving the tube. Number

four is the ring mounting that the transformer and tube are set in and allows circular motion of the tube. Number five is the fork mounting which rotates and allows the tube and transformer to be angled in and out. Number six is the tube port. The two devices just above it are the holding pin and lock pin for the cones and diaphragm that can be inserted into the port. Number seven indicates the location of the tube. On the right side of the tube is the opening for the filters."

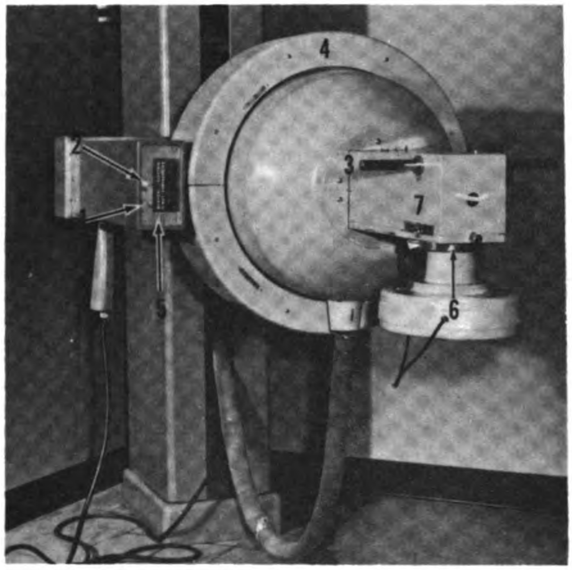



Figure 11-6 The Tube

THE CONTROL STATION. "The movement of the tube unit is accomplished with the use of motor driven devices. These devices are controlled with this portable hand control station. The various locks are magnetic and this station can unlock individual locks or all of them at once (Figure 11-7).

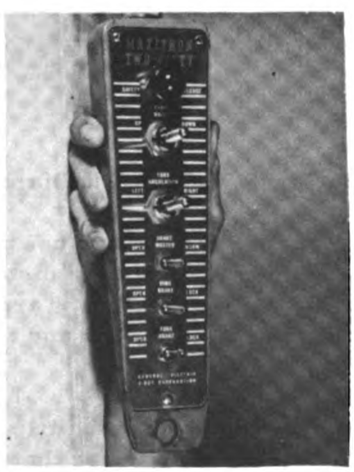


Figure 11-7 The Control Station

"To move the machine up and down, you have to move the fork mounting. The first switch on the top marked FORK HOIST is used for raising or lowering the tube. The fork mounting is angled with the FORK ANGULATION switch. The three brake switches that you see are used to release the magnetic locks of the ring and fork mountings. You may release the mountings individually, or with the master brake switch, all of them. Don't think you have broken something if you hear a definite clack or ping when the master brake switch is released - it's just releasing. The others may not make a sound.

"The large black knob at the top of the control station is the over-all safety switch. In case your machine ever does begin to run away from you, this black plug is pulled completely out of the control station. This action will cut all of the circuits and stop any movement of your tube unit."

OTHER EQUIPMENT. "The table, tube-unit and control station are only a part of the equipment you need for completing your treatment preparations. Let's look at this other equipment now."

The Visual Localizer Diaphragm. "You will notice that the tube on this machine has a large round bell-like device in the tube port. This is a visual localizer diaphragm (Figure 11-8). This device is lighted when on, and has lead shutters in it. The two large knobs on the sides are used to close down the field with the lead shutters. The other knob is to turn on the light. The light will show the exact field that is going to be exposed. When we position our patient, we can place him under the tube, turn on the light and adjust the shutters to the exact treatment area outlined on his body."

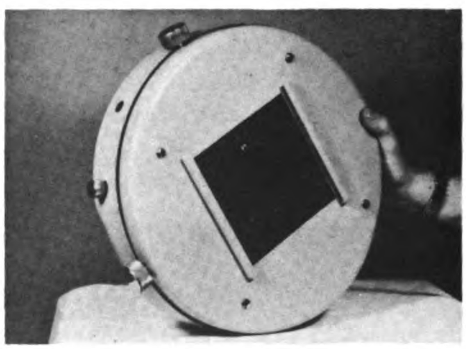


Figure 11-8 Visual Localizer Diaphragm

The Distance Calculator. "In deep therapy we use standard distances of 50 cm, 70 cm, and 100 cm. The distance we refer to is the distance between the target and the surface of the skin. This is abbreviated to TSD, Target-Skin Distance. You will also notice that we are using centimeters in therapy and not inches as you do in diagnostic radiography.

"Instead of a ruler or tape measure, we use a little device known as a distance calculator (Figure 11-9). It has a plexiplastic base that fits into slots provided for it on the underside of the visual localizer. A rod extends down from the center of this base. There are 50 cm, 70 cm and 100 cm extensions to this rod that can be screwed onto the base. These extensions can telescope up into themselves near the

end. This is in case of accident where the tube comes down on the patient with the rod in place. Before you can skewer the patient, the point will give."

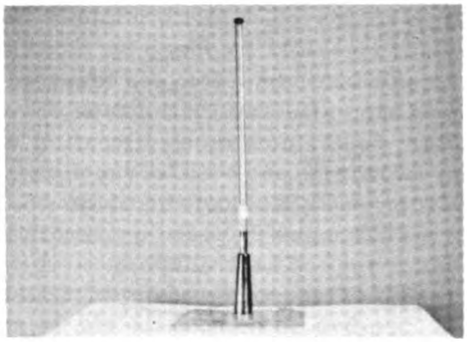


Figure 11-9 Distance Calculator

Filters. Filters are major parts of an X-ray therapy treatment. There are some treatments, however, where filters aren't used.

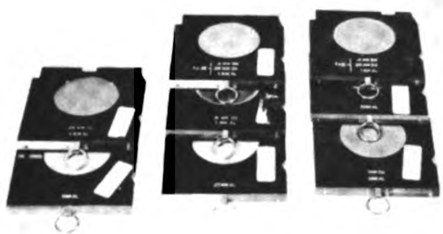


Figure 11-10 Therapy Filters, Deep

"The therapy filters that are used with this machine are clearly marked. You can see the different types of filters that we use. There are aluminum, combination of copper and aluminum, combination of tin, copper and aluminum. The type and amount of thickness of each metal is stamped on each filter and the border, near the ring, is colored."

"Just what do these filters have to do with therapy?" you ask.

"The filters influence the quality of the X-ray beam in therapy, just as it does in diagnostic radiation," Blank answers. "In therapy the beam must have a sufficient number of short wavelengths to penetrate the body to the tumor area. The filters block out or absorb the longer wavelengths.

"You not only have to know just how much radiation is being given to the patient, but you must know the quality of this radiation. Knowing the quality of the radiation is necessary to determine how far the X-ray penetrates and in figuring the dose or amount of radiation that is actually in the tumor area. We express the quality of an X-ray beam with the term HALF-VALUE LAYER. Half-value layer is the specific amount of filter needed to reduce the intensity of the X-ray beam in half. For ex-

ample, if our machine was producing a beam of 10 X-rays, of all wavelengths, and we placed a 1 mm thick sheet of aluminum under it that cut out 5 of the longer wavelengths, the half-value layer for that beam would be 1 mm of aluminum. You can see that with the 1 mm of aluminum filtering out the 5 longer wavelengths, you would have a better quality beam.

"Now the half-value layer of a beam of X-rays is affected by the amount of kilovoltage and filtration used. It is also affected by the type of metal that is used in the filter. Because of this, you must figure how much filtration would be needed at each KVP setting. One mm of aluminum will show different filtration of the beam at 250 KVP and 200 KVP. In other words, the quality of the beam would be different at these two KVP's. You will also see a difference in beam quality if you use a 250 KVP with a copper filter and an aluminum filter. The thickness of the filter will also show a change in the quality of the beam. The intensity would differ if you used 1 mm of aluminum and then 2 mm."

"This is certainly complicated," you say.

"Yes, it is a little difficult to understand at first," Blank says, "but maybe if I explain how this X-ray is stopped in various materials, it will help you understand better.

"Actually, the X-ray energy is ABSORBED in materials. In other words, the energy of an X-ray photon disappears into the atoms of a substance. Just remember that the energy is not destroyed, but disappears from its original form into some other form. Absorption is really the process by which the energy in a beam of X-ray is reduced as it passes through a substance. The energy is transformed into mass or other wavelengths of radiation by striking the electrons or the nucleus of the atom it hits. This disruption of the normal balance of energy, in the atoms of a substance like tissue, causes chemical and physical changes in that substance.

"Now, in filters, this absorption reaches a certain point and then begins to decrease, letting out long wavelengths, which formerly it absorbed, just as if there were a hole in the filter. What is happening? There are certain CRITICAL WAVELENGTHS in the beam, that are producing characteristic radiations from the absorbing material itself. You will remember from your physics that each material has certain characteristic radiation produced in it. It is for this reason that you have a number of metals for filters and different thicknesses of the same metal. When the beam produces, in the filter, the right type of wavelength which will cause it to produce its own characteristic radiation, its limits have been reached. Thus, a certain quality beam that causes 1 mm of aluminum to begin to emit radiation, instead of absorbing it, must have an added thickness to take care of this radiation, or the aluminum must be replaced with another type metal.

"Aluminum and copper are the more common filters because of their critical wave-lengths. Generally, the diagnostic machines do not generate the X-ray wavelength that will cause the production of their characteristic radiations. In therapy, however, such wavelengths are generated and you will find combinations of metals in various thicknesses. Where the critical wavelength is reached in one metal, causing it to produce its characteristic radiation, the other metal will absorb that radiation and the filtration quality will be increased. You should see the reason, now, for the combinations of metals in the filters that you have seen. The aluminum will absorb the characteristic rays of the copper. The air will absorb the radiations from the

aluminum. Thus, the aluminum blocks the hole in the copper. The metal with the highest atomic number is placed nearest the tube. Be sure to remember this.

"Those filters that are marked Thoraeus II and Thoraeus III are made up of a combination of tin, copper and aluminum. This type of filter allows the escape of more short wavelengths without as great an effect on the total intensity of the beam. Lead filters are used for supervoltage therapy machines. Materials, such as gold, platinum or silver are used to filter radium.

"You should begin to understand now, what the doctor meant when he said that he wanted 200 roentgens per field, Thoraeus II filter at 250 KVP. He wanted 200 roentgens, of a certain quality beam, that will be generated at 250 KVP through a Thoraeus II filter. This quality beam will cause a specific type of result in the tissue. All of the figuring is the doctor's work. What you have been told will help you understand the purpose of some of his directions or orders. Later on I'll tell you about the various doses. Filters have a bearing on the dosage received by the patient.

Figure 11-11 Filter Slot

"Let's put the Thoraeus II filter in the filter slot now," says Blank as he picks it out of the drawer. "We'll have that done before we get the patient set up."

Masking. "The next thing you should know about is the use of lead rubber masks. These are used to keep the radiation from exposing the areas around the port. They are made from sheets of lead rubber. They can be cut to the size of the field you are exposing. If you have a 5 x 5 cm field, you just cut the field in the sheet. The sheet is placed over the port to be exposed. This mask protects the regions around the field."

Cones. "While we're in here, let's look at some of the treatment cones that are used. These cones serve the same purpose in therapy that your cones do in diagnostic radiography. There are different types. The rectangular and square cones are designed to give a TSD of 50 cm. The bottoms of the cones are brought down to the skin surface and cover the port to be exposed (Figure 11-12).

"The superficial therapy cones provide a TSD of 21.5 centimeters.

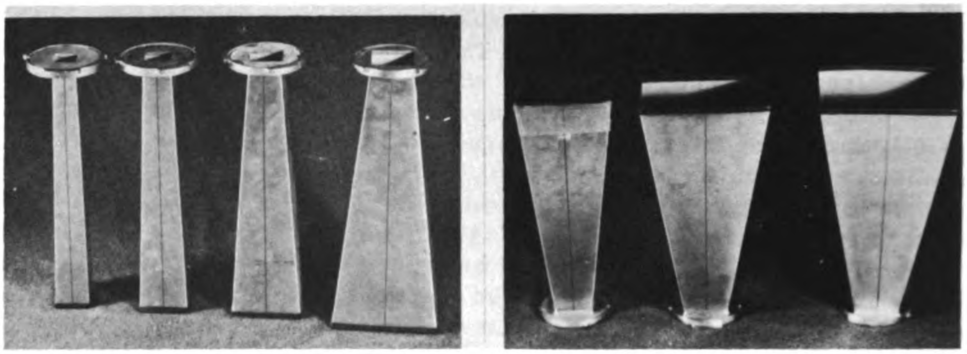


Figure 11-12 Treatment Cones

"There is an intra-cavity cone that is used to treat areas in the mouth or vaginal space. It is known as the visual intracavity therapy cone. The cone has a periscope device which permits the doctor to see the area to be treated so that accurate positioning can be obtained. The cones come in different diameters such as 2, 2.5, 3 and 3.5 centimeters."

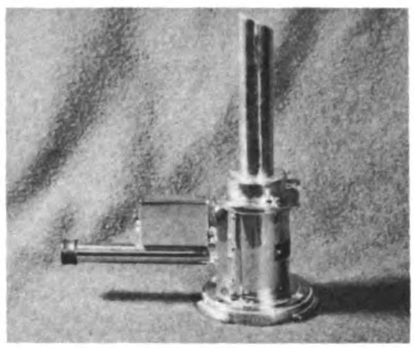


Figure 11-13 Visual Intracavity Therapy Cone

## POSITIONING THE PATIENT

The doctor comes back into the room after Sgt. Blank has finished telling you how to warm-up the control, explained about the tube and table, control station, and the other equipment. You watch him, now, as he prepares to place the patient into position. You have noticed that the areas that he marked out on the patient were areas that could be exposed while the patient was lyingon his back or stomach. Sgt. Blank places a clean sheet and pillow on the table. The doctor asks the patient to lie down on the table on his back. Sgt. Blank brings the distance calculator to the tube and inserts it. He turns on the light switch on the visual localizer diaphragm. The tube is too low, so he goes to the control station and raises it. The doctor unlocks the table by pulling up the lock lever and rolls the table under the tube. The light from the diaphragm shows on the patient's abdomen. The sergeant brings the tube down until the distance calculator just touches the skin. The doctor removes the distance

calculator and hands it to the sergeant. Then the doctor adjusts the shutters in the visual localizer until the light outlines the port marked on the skin. The sergeant brings the doctor a lead rubber mask, which the doctor places over the area to be exposed. He adjusted the table and diaphragm until he has the light outlined exactly within the opening of the mask. The doctor then locks the table by pushing the lock lever down.

"We're all ready to go now," the doctor tells you. "Sgt. Blank will tell you how to set your machine up for actual treatment operation, how to figure how much time you will need for the amount of roentgens I want, how to watch your patient and will then finish telling you how to complete the forms you started earlier. I will check everything before the actual treatment begins."

"I'd like to ask one question, doctor," you say. "Do you always use the PA and AP positions for therapy?"

"We generally try to use these positions because of the amount of time it takes to treat therapy patients. They sometimes are exposed for periods over five minutes. Patients wouldn't be able to hold strained positions for any length of time and it is very important that they do not move. If they move they will be exposed in areas that exposure is not needed and this is detrimental. Whenever a patient moves, the treatment must be stopped and the patient re-positioned. This is very important for you to remember.

"Usually we take a radiographic film of the patient in position to check the accuracy of our position. Sometimes we take it on the table in the treatment room with the patient set up as for a treatment. Generally, however, we take the film in the radiographic chamber. We place the patient on the table in the proper position, place the mask over the port and project the area revealed in the mask. In this manner, we can check to see if the field covers the tumor area we want to treat."

As you leave the room, the sergeant closes the door to the treatment room.

## SETTING UP CONTROL FOR TREATMENT

"Okay", Sgt. Blank begins. "You have seen the doctor and me attach the visual localizer to the machine. The patient has been positioned and masked. The filter was inserted into the filter slot. The only person in the room is the patient. And the treatment doors are closed.

"Looking at the treatment instructions that the doctor gave us, you can see that we are going to use 250 KVP, 30 MA, 70 cm TSD, a Thoraeus II filter and 200 roentgens to the right inguinal area. This area is to be our number one port. We also are going to treat number two port and number three port, the AP abdomen and AP chest ports. Number two port will receive 200 roentgens and number three, 300 roentgens."

ROENTGENS IN AIR. "We have been talking about roentgens and not about MAS you will notice. You will also see on the SF 524, the abbreviation 'r/a' after the dosages. This abbreviation means 'roentgens in air'. Because we cannot measure the exact number of roentgens within the tumor area deep in the body, we use the roentgens that are produced in air. These roentgens are produced in air and not in the tissue. The doctor has charted calculations which tell him that a certain percentage

of the radiation will reach the tumor area and cause reactions. You will recall that a roentgen is so many ion pairs produced in a certain amount of air. Ion pairs are also produced in tissue as the rays pass through, and because a certain percentage of them must be produced in the tissue before the rays even reach the tumor, all of the roentgens don't affect the tumor. These roentgens affect the normal tissue above the tumor. At any rate, the air is similar in atomic structure to the tissue of the body and readings in air provide a means of measuring the amount of ionization that may occur in the body. The effect of these roentgens are shown in the degree of biological change in the tissue.

"We are to give 200 roentgens in air. How do we get this? There is a chart posted near each machine which will show the amount of roentgens that are produced at certain KVP's, MA's filters and distances. These are roentgens produced per minute. In regular diagnostic radiography you use MAS or milliamperes times seconds. You know that if your machine is set at 10 MA, you will produce 10 MA per second. In therapy you are producing roentgens per minute. This is sometimes abbreviated 'RPM'. This chart is the calibration of the unit. Looking at this chart, you can see that at 250 KVP, 30 MA, Thoraeus II filter, and 70 cm. TSD, the tube will produce 33.3 'roentgens per minute'. Our techniques call for 200 roentgens. You will just divide the number of roentgens produced in one minute into the number of roentgens you want. Figure your time to the nearest second.

$$200 \div 33.3 = 6 \text{ minutes and } 3 \text{ seconds}$$

"You will expose your patient six minutes and three seconds every time you give a treatment with those factors. Each minute you will be exposing the patient to 33.3 roentgens in air." See Dosage Chart on Page 11-34.

OPERATING THE MACHINE FOR TREATMENT

"Again, you will see a chart that tells you how to operate the machine for an actual treatment. Follow each one of the steps. The doctor will check everything before the treatment begins. Watch me as I begin.

1. Check to see if you have the proper treatment devices on the tube. The doctor and I have done this already.

2. Position the patient. This has been accomplished.

3. Position the tube head. This is done.

4. Insert the desired filter into the tube slot. Looking at the filters again you will notice that there are different notches cut into the right side. Be sure that they are on the right side when you insert them in the filter slot. The notches also provide a code for the filter indicator light on your control panel.

5. Be sure that no one is in the treatment room but the patient.

6. Close your treatment room door. Check your panel light. It will be on.

7. Set the control panel timer to the proper time and turn the timer switch to ON. We are going to use 6 minutes and 3 seconds.

8. Turn your filter indicator knob until it lights up. Read the filter indicator to check, again, if you have the proper filter.

9. Set the milliampere switch to the proper position. You will remember that we left the unit setting on 30 MA after the warm-up.

10. Prepare the Integron IV, if your doctor uses it. He will explain.

11. Press the X-ray ON push-button.

12. Raise the KV to the setting you want; we will use 250 KVP.

13. Check the patient's position through the window in the wall and call the doctor. He will check over the settings for accuracy.

14. Push the SHUTTER OPEN button. The treatment is in progress.

15. Watch the patient during the treatment. He must not move. If he does, stop the unit.

16. When the unit clicks off, leave it energized for the next treatment.

"That's all there is to it," Blank says. "While the doctor is positioning the patient for the next field, we will return to our SF 524, Roentgen Therapy form and complete it up to this point."

## COMPLETING THE SF 524, ROENTGEN THERAPY

"We have left some information off the 'Physical Factors' section. You know now that we are using a 250 KVP Maxitron unit, 33.3 roentgens in air per minute and, from the Thoraeus II filter I showed you, that the filter had .4 mm Sn (Tin), .25 mm Cu (Copper) and 1 mm Al (Aluminum). This information will help us complete the physical and time factors on our form. The HVL (half-value layer) is found in the calibration book, provided by the physicist at the time the unit was first installed and calibrated. Looking at the book you will find that the half-value layer of the Thoraeus II filter at 250 KVP is 2.6."

### QUALITY OF RADIATION
### Visual Localizer

Maxwell AFB
Montgomery, Alabama
Maxitron 250

| KVP | FILTER | HALF-VALUE LAYER |
|---|---|---|
| 100 | None | 2.00 mm. Al |
| 100 | 0.50 mm. Al | 2.52 mm. Al |
| 140 | 0.25 mm. Cu | 0.52 mm. Cu |
| 200 | 0.50 mm. Cu | 1.15 mm. Cu |
| 250 | 0.50 mm. Cu | 1.40 mm. Cu |
| 250 | Thoraeus II | 2.60 mm. Cu |

"You fill out this form until it is complete," Sgt. Blank tells you.

You take the form and complete the physical and time factor sections.

Standard Form 524
Revised October 1953
Promulgated by
Bureau of the Budget
Circular A-32 (Rev.)

**CLINICAL RECORD** | **ROENTGEN THERAPY**

| DIAGNOSIS | SEX | RACE | AGE | DATE OF REQUEST |
|---|---|---|---|---|
| | | | | |

| PHYSICAL FACTORS | | | | | | | | | | TIME FACTORS | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TECH NO. | X-RAY APPARATUS | KV | ADDED FILTER mm. | | | | HVL mm. | MA | TSD cm. | r/MIN (AIR) | NO. FIELDS DAILY | INTERVALS | SIG. (Init) |
| | | | | SN | CU | AL | | | | | | | |
| 1 | 250 Maxitron | 250 | THII | .4 | .25 | 1 | 2.6 | 30 | 70 | 33.3 | 3 | 4D | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |

Figure 11-14 SF 524 (Front)

"Okay, that's done," you say. "What's next?"

"Turn the form over to the back," the sergeant tells you. "You will see where we keep a daily record of the treatment that is given to the patient. You will write out these factors each time you give a treatment. This is where you must remain alert and be sure that you practice the greatest accuracy possible. Immediately after finishing a treatment, record it. There can be no excuse for forgetting.

"We have treated port number 1; today is July 5th, 1957; the skin area treated was the right inguinal area; we used a 6 x 10 cm field; our factors were 250 KVP, 70 cm TSD, Thoraeus II filter, 6 minutes and 3 seconds. This gave us 200 r daily for a total of 200 r to that area. When you put this down, you will initial the last column. I will take this other form and fill it out with the probable course of this treatment so you can see what needs to be done. I want you to notice under the last dosage column 'Total r Air Skin' that each port is added consecutively. Look at this sheet and study the entries closely.

"You may have to use the backs of several SF 524's to make a complete record of all of the treatments the patient received. Be sure to write in the identification on the bottom of each form and keep the forms attached securely together. Remember to replace all of your forms into the proper case envelope right after you finish making the entries."

"What about the 'Dose' section on the front?" you ask.

"That section is filled in when the treatment is ended. The doctor may use it and he may just enter that information on the SF 525, Roentgen Therapy Summary. Also when there are a number of ports being used, as in this case, there may not be enough space to give the entire treatment. The heading 'Angle' under the Exposure Factors section will show any angles necessary, such as 7 degrees caudad, etc. All of the information that the doctor feels is necessary will be included on one of the forms.

| NO | DATE | SKIN AREA | FIELD SIZE | KV | TSD | FILTER | TIME | DAILY r AIR SKIN | TOTAL r AIR SKIN | | INIT. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5/7/57 | Rt Inguinal | Cm 6 x10 | 250 | 70cm | TH II | 6 min 3 sec | 200 | 200 | | JTB |
| 2 | 5/7/57 | Ant Abdomen | 10x30 | 250 | 70cm | TH II | 6min 3 sec | 200 | 200 | | JDB |
| 3 | 5/7/57 | Ant Chest | 5 x 5 | 250 | 70cm | TH II | 9min | 300 | 300 | | JTB |

"The orders were to alternate between anterior and posterior fields so on the 6th of July you would treat the posterior ports."

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | 6/7/57 | Post Abdomen | 10x30 | 250 | 70cm | TH II | 6 min 3 sec | 200 | 200 | | JTB |
| 5 | 6/7/57 | Post Chest | 5 x 5 | 250 | 70cm | TH II | 9 min | 300 | 300 | | JDB |

"You have now treated all of the ports at least once. You will start again with port number 1 on the 7th of July. Notice the total column."

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 7/7/57 | Rt Inguinal | 6 x10 | 250 | 70cm | TH II | 6 min 3 sec | 200 | 400 | | JDB |
| 2 | 7/7/57 | Ant Abdomen | 10x30 | 250 | 70cm | TH II | 6 min 3 sec | 200 | 400 | | JDB |
| 3 | 7/7/57 | Ant Chest | 5 x 5 | 250 | 70cm | TH II | 9 min | 300 | 600 | | JTB |
| 4 | 7/8/57 | Post Abdomen | 10x30 | 250 | 70cm | TH II | 6min 3 sec | 200 | 400 | | JTB |
| 5 | 7/8/57 | Post Chest | 5 x 5 | 250 | 70cm | TH II | 9 min | 300 | 600 | | JTB |
| 1 | 7/9/57 | Rt Inguinal | 6 x10 | 250 | 70cm | TH II | 6 min 3 sec | 200 | 600 | | JTB |
| 2 | 7/9/57 | Ant Abdomen | 10x30 | 250 | 70cm | TH II | 6 min 3 sec | 200 | 600 | | JDB |
| 3 | 7/9/57 | Ant Chest | 5 x 5 | 250 | 70cm | TH II | 9 min | 300 | 900 | | JTB |
| 4 | 7/10/57 | Post Abdomen | 10x30 | 250 | 70cm | TH II | 6 min 3 sec | 200 | 600 | | JDB |
| 5 | 7/10/57 | Post Chest | 5 x 5 | 250 | 70cm | TH II | 9 min | 300 | 900 | | JDB |

Figure 11-15 SF 524 (Back)

"While we are pretending, let's go ahead and imagine that we have completed the treatment on this patient. By doing this, I can show you how the SF 525, Roentgen Therapy Summary, is completed."

## ROENTGEN THERAPY SUMMARY, SF 525

"The ward physician fills out the first part of the sheet, but sometimes you will do this from information you have available on the patient. You will make two copies of this form. The pre-therapy diagnosis is entered, the sex, age and date are placed in the spaces provided for them. A brief clinical history is inserted in the proper space and the doctor will sign it. The section that is marked 'Description of Treatment' is filled out by the radiologist. The exposure factors and dose information is

entered. This information can be found from the SF 524, Roentgen Therapy form. You need the dates of the treatment, number of treatments and the number of days the treatments were given in. If the dose was to one particular area, the daily dose is entered. In the 'Summary of Treatment' section, the more detailed information is entered. At the bottom, of course, is the identifying information. Study this form carefully and you can see that it is not difficult to complete. The doctor will need information from your SF 524. With this and his progress notes he will dictate the results, reactions or complications that were observed about the treatment. You will keep one copy in your file and the other will be sent to the physician who sent the patient to the clinic. This copy is made a part of the patient's clinical record. See SF 525, Roentgen Therapy Summary, page 11-35.

"The doctor may want to write a narrative summary to supplement the roentgen therapy summary. These forms are kept in the Registrar's Office. The form is SF 502, Narrative Summary. If there is more information to be written than will go on one form, the rest is placed on additional copies of this form. Each form must be signed and dated and the identification information of the patient placed on it. Two copies are made, one to be included in your file and the other for the attending physician for inclusion as part of the patient's clinical record. See SF 502, Narrative Summary, page 11-36.

"I guess that will about complete your learning for today."

"Yes, I have sure found out that there are a number of things that a person has to know about therapy," you say. "Let's see, there was the greeting of the patient, checking the appointment schedule and seeing that he had two copies of an SF 513, Consultation Sheet. These were given to the doctor to put his course of treatment on them and one copy we keep here; the other goes back to the requesting physician. I found out that a typical therapy section has a deep therapy unit, superficial therapy unit, a doctor's office and a reception section. When a new patient comes for treatment, the ledger is filled out with a case number assigned to the patient and other identification information is taken. Three 3 x 5 index cards are made; one for the files and the other two for the pathology cross-index file. I learned how the various forms are filed under their form numbers and what each of these forms were. I see that the technician assists the doctor in marking out the various treatment fields or ports. I know how to fill out the Urinalysis, Blood Chemistry, Hemotology, and Laboratory Reports forms. I know that we must weigh the patient and take a PA and a lateral chest on the patient. I know about the SF 509, Doctor Progress Notes and the Radiographic Reports form.

"I know about treatment instructions and what is meant by KVP, filters, TSD, and alternate ports daily. I realize the importance of keeping the SF 524 accurate and understand how this form is filled out. I am aware of what kind of machine is used for deep therapy, the 250 GE Maxitron. The control panel is familiar to me now and I can warm-up the unit the first thing in the morning by using the warm-up check list. I can operate the unit for treatment by using the check list. The table operation is clear to me. I no longer need wonder how to move the tube unit around because I now know how easy it is with the portable control station. I am familiar now with the visual localizer diaphragm, the distance calculator, how to make masks and what they are used for, and what difference there is in therapy filters, how to identify them and where they go in the unit. I am also familiar with what filters do, how they absorb some of the long wavelengths, how they can produce their own critical wavelengths after reaching certain KVP's, the meaning of HVL (half-value layer) and why

we have combinations of metals. I see the difference between MAS and 'roentgens per minute' and know how to find the treatment dosage from the calibration chart near the unit. I know that various types of treatment cones are used in therapy too. I have a better idea of why the doctor uses the AP and PA position in therapy. I can remember that the position is checked by taking a radiographic film of the port for accuracy. At the end of treatment a SF 525, Roentgen Therapy Summary sheet is made, and the information is taken from the detailed treatment provided by the SF 524, Roentgen Therapy form. I also know that the doctor may want to make a treatment summary in narrative form and that this form, SF 502, Narrative Summary, is obtained from the Registrar's Office.

"You've done well to learn this as you have," says Blank. "We will take up the calibration of the X-ray units and how we use the Victoreen 'r' meter in doing this calibration tomorrow."

## CALIBRATION OF THE THERAPY MACHINE

The next morning you return to the therapy section. Sgt. Blank greets you and tells you that he will show you how to calibrate the machine. You and the sergeant wait for the doctor to arrive. While you wait, Blank begins to show you what is necessary to get the machine calibrated.

"Calibration," he begins, "is the process where we check the amount of roentgens that are being produced from the tube. We need to know how many roentgens are passing through each type of filter and we need to know what the concentration of these roentgens are at each distance we use in therapy. We need to calibrate the machine at various intervals because as you use the machine its output will vary. When the machine was first installed, the company physicist calibrated the machine. We must make spot checks periodically to see what change has been made in the output. This is usually done at least once each month. Technically the doctor is responsible for the accurate calibration of the unit and that is why we are waiting for him. We will assist him in the calibration of the unit.

"Before you start to calibrate the machine you must remember that the roentgen is the amount of ions produced in 1 cc of air at $0^{\circ}$ Centigrade. The temperature and pressure of the air at any particular moment, here in the clinic, is not the ideal laboratory condition at which you must figure. You must compensate for this by converting the present atmospheric conditions to the standard temperature and pressure. Each "r" meter that is used in a department is furnished with an 'Air Density Correction Table'. You will take the temperature of the room. To find the barometric pressure, you may call your local or base weather station. Take the two figures and find them on the table provided with the meter. The figures that they intersect will represent the converted temperature and pressure and show you the amount of roentgens you are producing. Remember that there is only a certain number of air molecules in 1 cc at $0^{\circ}$ Centigrade and 760 mm of mercury pressure. If the pressure is increased, the air will be denser."

"I would certainly never have thought of that," you say.

"No, you wouldn't if you have never calibrated a therapy machine," Sgt. Blank

injects. "But, now, let's take the temperature and find the pressure for today."

You check the thermometer, while Sgt. Blank calls the base weather station.

VICTOREEN "R" METER

"Come with me," Blank directs, "and I'll show you what we use to measure the amount of roentgens produced in calibrating the machine. You will remember that X-rays ionize air. It is this principle that we use in measuring. We use what is known as a thimble chamber. This chamber has a very thin charged wire in it. When this chamber is set in the path of an X-ray beam, the ionization in the air causes the wire to become discharged. If the wire has negative charges on it, then it will attract the positive ions in the air or vice versa. The X-ray beam will produce so many ion pairs in a roentgen. In case the wire was charged with more negative charges than the X-ray produced positive ions, then you could read what was left of the negative charges on a meter. In other words, the positive ions would combine with the negative charges and neutralize. The negative charges left would indicate the number of roentgens produced. The more roentgens you produce, the more charge that would be neutralized.

"Most Air Force clinics that have therapy will use the Victoreen 'r' Meter. (Figure 11-16). It is a thimble type ion chamber. It is used to calibrate the number of roentgens that are being produced, in air, from the tube. The unit consists of two parts. These parts are the electrometer and the thimble chamber. This unit is a condenser type instrument.

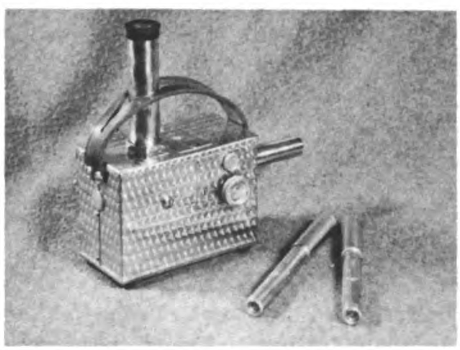


Figure 11-16 Victoreen 'r' Meter

"The box is the electrometer. This is where the chambers are read and charged. You will see that there are three cylinders. These are the thimble chambers. There is a bayonet type sleeve cover over each thimble. Remove this and you will see a little red tip. This is the air chamber. These chambers will reach up to 25 r, 100 r, and 250 r respectively. Usually we use the 100 r chamber for calibrating the 250 Maxitron. You must use extreme caution in handling these chambers. Do not bump or drop them. If you do, you may cause the charge to leak or damage the chamber."

OPERATION OF METER. "Remove the 100 r chamber from the case. Remove the electrometer. Place the chamber into the front of the electrometer. Be sure to remove the sleeve from the chamber. Press down the button on the lower left front

of the electrometer and then look through the periscope or eye piece on top of the instrument. You will see a scale with three types of reading for the 25 r, 100 r, and 250 r chambers. Discharge the unit. You do this by turning the little knob on the upper left hand side back to you. This button turns on the light. Still pressing the light button turn the large knob on the upper right hand side until the hair line on the scale is set to zero. Charge the chamber by pushing IN the little knob on the upper right side and turning it clockwise. When the unit is charged replace the sleeve cover.

"Once the unit is charged, we will take the chamber into the therapy room. The chamber is suspended within the center of a 10 x 10 centimeter field. You can make this field by measuring it off on a piece of film box cardboard. Placing this cardboard under the tube, turn on the visual localizer and adjust the shutters so that the light covers the area outlined on the cardboard. Place your chamber so the red tip is in the center of this field. Do not let your chamber tip touch any subject. Also make sure that the thimble chamber is at least 36 inches above the floor so that you receive no backscatter into the chamber. Place the distance calculator that you are going to use into the visual localizer and bring the tube down to the thimble chamber until the tip of the calculator is on the same level with the chamber. You are now ready to turn on the machine for a reading.

"You make three exposures with each distance, KVP, MA, filter. Each exposure will be for a period of one minute because you want to know the 'roentgens per minute'. It is better to expose for one minute than exposing for fractions of a minute and then multiplying. However, if you are calibrating the tube without a filter, you should not make the exposure more than 15 seconds because the chamber will go beyond its capacity to read the roentgens produced. In other words, you will produce more roentgens than the chamber can read, so the exposure would not be of any value. Using 15 seconds you can multiply by four and find out how many roentgens are produced in one minute without a filter. The three exposures you make are used to find the average exposure produced by the tube. You will record the amount produced for each exposure, add them together and then divide by three to find the average. This average is the figure you will use as the output for your machine.

"Okay, we have our chamber set, so we will make our minute exposure and then I will show you how we read that exposure on the meter."

The machine is set and the filter placed in the machine. The exposure is made and Sgt. Blank gets the chamber from the therapy room and brings it back to the electrometer.

"Now, I'll remove the protective sleeve and place the chamber back into the front of the electrometer. Pushing the light button on the lower left hand side, I will look through the eye piece and read the scale marked 100 r because I have used the 100 r chamber. The reading is recorded and I discharge the unit by turning the little knob on the upper left hand side back toward me. I will reset the hair line, with the big knob on the upper right hand side, to zero. The unit will be recharged by pushing in the little knob on the upper right hand side and turning it clockwise. The thimble is removed from the electrometer, the sleeve cover is replaced and we are ready for another reading. Remember that we must have three readings for each setting and filter."

## CALIBRATION LEDGER

"That isn't as hard as I thought it would be," you tell Blank.

"It isn't very difficult once you have done it," he replies. "But, now, you must see that each of these readings are recorded. You have to check each filter at each KVP, MA and distance. You will need a ledger to record this. You should have a section in the ledger for each machine that you calibrate. If you have a deep therapy unit and a superficial therapy unit, you will need to calibrate each one separately. The ledger should have spaces for KVP, MA, Filter, Distance, roentgens per minute (average of the three exposures), Barometric Pressure, Temperature, Date of Calibration and Remarks. Look at this for an example.

| KVP | MA | Filter | Distance | 'R' per min | Pressure | Temp | Date |
|---|---|---|---|---|---|---|---|
| 200 | 30 | 1 AL | 50 Cm. | 33.8 | 29.89 | 72 | 6/5/57 |

"Remember, each time you change some factor - KVP, MA, filter or distance- you will have to calibrate it with all the other factors. As you can see, this will take time. You will generally calibrate your unit on week-ends and it will take two normal eight-hour days to do this, depending upon the number of machines you have and the number of filters that you have.

"Calibration is also made for various types of special ports that may be used for breast cancer, etc. The fields are mapped out and a reading is obtained so that you know exactly what exposure is applied in these special fields. These special calibrations will usually be entered in the remarks section of your ledger. There are special means of calibrating the exposure when using treatment cones. Your doctor will explain these to you.

"You should now know how to use the Victoreen 'r' Meter, how you use it in setting up your field and how to record your measurements in the ledger. You should also realize that the radiologist is going to be working with you and will supervise what you are doing.

"Here he comes now. We will begin over again and you can follow us through so that you can imbed this information in your mind."

## SUMMARY

"You are now familiar with the therapy section. You know the records that are kept and how they are prepared. You are aware of the type of machine you will use and the principles on which it operates. You know about the localizer, masks, distance calculator, and cones. Filters have meaning for you now. Setting up the machine and arriving at the proper technique is now familiar. And you know the procedure of using the Victoreen 'r' Meter and how to calibrate your machine.

"You have received only a small portion of the tasks that are done in the therapy section. In the seven-level manual, you will learn the rest. You have the basic knowledge of the therapy section."

Standard Form 514
Rev. Feb. 1961
Promulgated
By Bureau of the Budget
Circular A—32

**CLINICAL RECORD** | **LABORATORY REPORTS**

ATTACH 3D REPORT ALONG HERE ↑ AND SUCCEEDING ONES ON ABOVE LINES

ATTACHING MARGIN

| PATIENT'S LAST NAME—FIRST NAME—MIDDLE NAME | REGISTER NO. | WARD NO. |
|---|---|---|
| Able, Ima Conabe | 119058 | 1 |

| REQUESTED BY | DATE OF REQUEST |
|---|---|
| Dr. E.R. Green, Capt | 1[illegible] Jul 57 |

(Above space for mechanical imprinting, if used)

(Check one) ☐ BED PATIENT ☒ AMBULATORY

| CHECK (✓) | EXAM. REQUESTED | RESULTS | CHECK (✓) | EXAM. REQUESTED | RESULTS | CHECK (✓) | EXAM. REQUESTED | RESULTS |
|---|---|---|---|---|---|---|---|---|
| X | W. B. C. | 2,100 | | R. B. C. | | | PLATELETS | |
| | DIFFERENTIAL COUNT | | | | | | SEDIMENTATION RATE | |
| | NEUTROPHILS | | | HEMOGLOBIN | | | HEMATOCRIT | |
| | LYMPHOCYTES | | | BLEEDING TIME | | | BLOOD GROUP | |
| | MONOCYTES | | | COAGULATION TIME | | | Rh TYPE | |
| | EOSINOPHILS | | | BLOOD MORPHOLOGY | | | | |
| | BASOPHILS | | | MALARIA SMEAR | | | | |

| OTHER TESTS OR EXAMINATIONS (Specify) | REMARKS |
|---|---|
| | Radiation Check |

| DATE OF REPORT | SIGNATURE (Specify lab. if not part of requesting fac.) | NAME OF HOSPITAL OR OTHER MEDICAL FACILITY |
|---|---|---|
| 16 Jul 57 | D. F. Brown 1/Lt USAF (MSC) | 3810th USAF Hosp., MAFB, Ala. |

Standard Form 514b—Rev. August 1954. Promulgated by Bureau of the Budget—Circular A-32 GPO 16—59374-1 † **HEMATOLOGY**

**STANDARD FORMS 514a THROUGH 514m WILL BE ATTACHED TO THIS SHEET**

| PATIENT'S LAST NAME—FIRST NAME—MIDDLE NAME | REGISTER NO. | WARD NO. |
|---|---|---|
| Able, Ima Conabe A/2c | 119058 | 1 |

3810th USAF Hosp., MAFB, Alabama
(NAME OF HOSPITAL OR OTHER MEDICAL FACILITY)

GPO 16—69904-1 †

**LABORATORY REPORTS**
Standard Form 514

Standard Form 519
Rev. August 1954
Promulgated By Bureau
of the Budget Circular A-32

**CLINICAL RECORD** | **RADIOGRAPHIC REPORTS**

72789

PATIENT'S LAST NAME—FIRST NAME—MIDDLE NAME

ABLE, IMA GONABE AF 0000111 A/2c

REGISTER NO. 119058

WARD NO. X-ray

AGE 24

SEX M

(Check one) ☐ BEDSIDE, WHEELCHAIR, OR STRETCHER ☐ BED PATIENT ☒ AMBULATORY

EXAMINATION REQUESTED: PA Chest

REQUESTED BY: Dr. E.R.Green, Capt.USAF(MC)

DATE OF REQUEST: 27 Jul 57

(Above space for mechanical imprinting, if used)

PERTINENT CLINICAL HISTORY, OPERATIONS, PHYSICAL FINDINGS, AND PROVISIONAL DIAGNOSIS

For Therapy Records

FILM NO. 26815A

DATE OF REPORT 30 Jul 57

RADIOGRAPHIC REPORT

Chest: The metastatic lesion overlying the 2nd anterior interspace on the right has almost completely disappea red. A questionable area of persistent infiltrate may still be present and overlying the 6th posterior rib on the right. The lung fields otherwise are clear, there are no other metastases seen. The heart and mediastinum are normal. The bony thorax is intact. No other abnormalties are seen.

Impression: The post x-ray therapy film shows disappearance of right upper lobe solitary metastasis.

E. R. Green, Capt. USAF(MC)

SIGNATURE: (Specify location of laboratory if not part of requesting facility)

3810th USAF Hospital, MAFB, Alabama

(NAME OF HOSPITAL OR OTHER MEDICAL FACILITY)

Standard Form 519A (Rev. Aug. 1954)
Promulgated by Bureau of the Budget Circular A—32 (Rev.)

RADIOGRAPHIC REPORT

3810th USAF Hospital, MAFB, Alabama

(NAME OF HOSPITAL OR OTHER MEDICAL FACILITY)

Standard Form 519A (Rev. Aug. 1954)
Promulgated by Bureau of the Budget Circular A—32 (Rev.)

RADIOGRAPHIC REPORT

PATIENT'S IDENTIFICATION (For typed or written entries give: Name—last, first, middle; grade; date; hospital or medical facility)

Able, Ima Conabe A/2c 5 Jul 57
3810th USAF Hospital
Maxwell AFB, Alabama

REGISTER NO. 119058

WARD NO. 1

RADIOGRAPHIC REPORTS
Standard Form 519

U. S. GOVERNMENT PRINTING OFFICE 16—58295-3 †

Standard Form 509
Promulgated August 1945
By Bureau of the Budget
Circular A—32

| CLINICAL RECORD | DOCTOR'S PROGRESS NOTES (*Sign all notes*) |
|---|---|
| DATE | |
| 5 Jul 57 | Weight: 160 lbs |

(*Continue on reverse side*)

| PATIENT'S LAST NAME—FIRST NAME—MIDDLE NAME | REGISTER NO. | WARD NO. |
|---|---|---|
| Able, Ima Gonabe A/2c | 119058 | 1 |

3810th USAF Hosp Maxwell AFB, Alabama
(NAME OF HOSPITAL OR OTHER MEDICAL FACILITY) 16—54183-2

DOCTOR'S PROGRESS NOTES
Standard Form 509

## DOSAGE CHART

## CERTIFICATE OF STANDARDIZATION OF X-RAY MACHINE

3810th USAF Hospital
Maxwell Air Force Base
Montgomery, Alabama

Certified Radiation Physicist

| 1<br>Peak Kilovolts | 2<br>Primary Volt Meter With Load | 3<br>Milliamperes | 4<br>Distance Cm. | 5<br>Added Filter | 6<br>Roentgens per min. in air |
|---|---|---|---|---|---|
| LIGHT LOCALIZER: | | | | | |
| 250 | 250 | 30 | 50 | 1/2 Cu plus 1 Al | 113 |
| | | | 50 | Thoraeus II | 63 |
| 250 | 250 | 30 | 70 | 1/2 Cu plus 1 Al | 57 |
| | | | 70 | Thoraeus II | 33.3 |
| 250 | 250 | 30 | 100 | 1/2 Cu plus 1 Al | 27-1/2 |
| TREATMENT CONES | | | | | |
| 250 | 250 | 30 | 50 | Thoraeus II | 69 |
| PERISCOPE WITH INTRA-ORAL CONES (Straight Edge) | | | | | |
| 200 | 200 | 30 | 40 | 1/2 Cu plus 1 Al | 105 |
| PERISCOPE WITH INTRA-ORAL CONES (Beveled Edge) | | | | | |
| 200 | 200 | 30 | | 1/2 Cu plus 1 Al | 116 |

| | | |
|---|---|---|
| DATE: 10 Jul 57 | MACHINE: General Electric<br>MAKE: Maxitron<br>TYPE: 250 | SIGNATURE:<br>J.D. Check |

Standard Form 595
Promulgated May 1950
By Bureau of the Budget
Circular A-32 (Rev.)

**CLINICAL RECORD** | **ROENTGEN THERAPY SUMMARY**

*(To be filled out by Ward Physician)*

| PRE-THERAPY DIAGNOSIS | SEX | AGE | DATE |
|---|---|---|---|
| Teratoma with metastasis, right testicle | M | 24 | 16 Aug 57 |

BRIEF CLINICAL HISTORY

Intermittent swelling and pain of the right testicle since July 1955. April 1957 sharp pain noted in right flank, radiating into the right iliocostal space. Admitted 3 Apr 57, Keesler AFB, for neoplasm of right testicle. Air evacuated to Maxwell AFB for deep therapy.

(Signature of Physician)

**DESCRIPTION OF TREATMENT**
*(To be filled out by Radiation Therapist)*

FACTORS: 250 KV. 30 MA. TH II FILTER 2.6 HVL 33.3 r/min
70 CM. TARGET SKIN DISTANCE

DOSE: FROM 5 Jul 57 TO 16 Aug 57 THE PATIENT RECEIVED 60 X-RAY TREATMENTS OVER A PERIOD OF 43 DAYS

THE DAILY DOSE WAS

**SUMMARY OF TREATMENT**

| PORTAL NO. | AREA | FIELD SIZE (CM) | TOTAL ROENTGENS DELIVERED (Check one) ☐ IN AIR ☐ TO THE SKIN |
|---|---|---|---|
| 1 | Anterior Abdomen | 10 x 30 | 200 x 8, 300 x 2 - 2200 r/a |
| 2 | Right Inguinal | 6 x 10 | 200 x 8, 300 x 2 - 2200 r/a |
| 3 | Anterior Chest | 5 x 5 | 300 x 9, 200 x 1 - 2900 r/a |
| 4 | Posterior Chest | 5 x 5 | 300 x 9, 200 x 1 - 2900 r/a |
| 5 | Posterior Abdomen | 10 x 30 | 200 x 9, 300 x 1 - 2100 r/a |
| 6 | | | |
| 7 | | | |
| 8 | | | |
| 9 | | | |
| 10 | | | |

TOTAL AMOUNT OF X-RAY DELIVERED

SAME AS ABOVE

THE TOTAL DOSE TO WAS r/in DAYS

RESULT OF TREATMENTS, REACTIONS, COMPLICATIONS. Therapy was discontinued after delivery of a minimum of 1300 r tissue does to the right inguinal, abdominal, periaortic and mediastinal areas and the metastasis in the right upper lobe. Treatment was delivered over a period of 43 days. During this time the patient developed a leukopenia with low levels approaching 2500 WBC. The pulmonary metastasis disappeared. However, toward the end of treatment, the patient began complaining of increasing amounts of right lower abdominal pain and a mass re-appeared in the right flank. Repeat IVP's revealed a progressive hydronephrosis on the right and progressive enlargement of a retroperitoneal mass overlying the right psoas shadow. Because of evidence of recurring tumor in the face of continued treatment, x-ray therapy was discontinued. Possible future therapy may be given in the form of nitrogen mustard. No future x-ray therapy is contemplated.

| SIGNATURE OF PHYSICIAN | DATE | IDENTIFICATION NO. | ORGANIZATION |
|---|---|---|---|
| E.R. Green, Capt. USAF (MC) | 29 Aug 57 | AF 0000111 | 5705th AB Gp |

| PATIENT'S LAST NAME—FIRST NAME—MIDDLE NAME | REGISTER NO. | WARD NO. |
|---|---|---|
| Able, Ima Gonabe A/2c | 119058 | 1 |

3810th USAF Hospital, Maxwell AFB, Alabama
(NAME OF HOSPITAL OR OTHER MEDICAL FACILITY)

**ROENTGEN THERAPY SUMMARY**
Standard Form 595

U. S. GOVERNMENT PRINTING OFFICE 16—61560-1

520926—GAFB—24 Jan 52—3M Auth: Ind. Req 52-P-525

Standard Form 502
Rev. Feb. 1951
Promulgated
By Bureau of the Budget
Circular A—32

| CLINICAL RECORD | NARRATIVE SUMMARY | |
|---|---|---|
| DATE OF ADMISSION | DATE OF DISCHARGE | NUMBER OF DAYS HOSPITALIZED |
| 5 Jul 57 | Transferred to Maxwell AFB | 91 |

*(Sign and date at end of narrative)*

Transfer Summary

History of Present Illness:

Past History:

Physical Examination:

Laboratory Findings:

Course in Hospital:

Disposition:

Diagnosis:

*(Use additional sheets of this form (Standard Form 502) if more space is required)*

| SIGNATURE OF PHYSICIAN | DATE | IDENTIFICATION NO. | ORGANIZATION |
|---|---|---|---|
| James G. White, CAPT. USAF (MC) | 2 Jul 57 | AF 0000111 | 5705th AB Gp |

| PATIENT'S LAST NAME—FIRST NAME—MIDDLE NAME | REGISTER NO. | WARD NO. |
|---|---|---|
| Able, Ima Gonabe A/2c | 1190586 | 14 B |

NARRATIVE SUMMARY
Standard Form 502

(NAME OF HOSPITAL OR OTHER MEDICAL FACILITY)

U. S. GOVERNMENT PRINTING OFFICE 16—56190-3

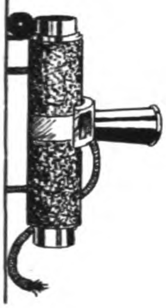
## QUESTIONS

1. What will be your three primary duties in the therapy section?
2. Explain how the pathology file is administered.
3. List the forms used in the therapy section.
4. Explain how you fill out the SF 524, Roentgen Therapy.
5. Explain how you would go about warming-up your machine control panel.
6. Explain the operation of the Therapy table.
7. What is the visual localizer diaphragm and how is it used?
8. What is the distance calculator? Explain its construction and types.
9. What is the difference between a therapy filter and a diagnostic filter?
10. What do the filters do to the X-ray beam and how do you express the quality of the X-ray beam?
11. What affects the half-value layer of a beam of X-rays?
12. Why is there a combination of metals in some X-ray filters? What metals are contained in "Thoraeus" filters?
13. What are the various types of cones used in the therapy section?
14. Explain why patients are generally positioned in the AP or PA position.
15. What does "r/a" mean?
16. What does "rpm" mean?
17. What do you use in figuring the amount of X-ray you want for a treatment?
18. What does "qd" mean?
19. How is SF 525, Roentgen Therapy Summary filled out?
20. What is SF 502, Narrative Summary used for in the therapy section?
21. Why is it important to know the temperature and barometric pressure when you calibrate a therapy machine?
22. What is a "Air Density Correction Table" used for in therapy?
23. What is the Victoreen 'r' Meter. Explain how you operate the Victoreen 'r' meter.

24. Explain how you set the thimble chamber up in the field during calibration.

25. What information is entered in a calibration ledger?

26. Check the immediate area to see if there are any hospital facilities that are using therapy. Visit the hospitals and observe the procedures and equipment. Make notes of these visits and the things you have seen.



# CHAPTER 12

## EQUIPMENT MAINTENANCE

Equipment maintenance is a direct responsibility of every technician in an X-ray clinic. The proper use and care of the equipment is one of your supply responsibilities. However, because of the complexity of X-ray equipment there is a limitation on the amount of maintenance and repair you are permitted to perform. Generally your maintenance will consist of very minor repairs. This chapter is presented more as a guide on what malfunctions can occur, what may be causing this malfunction, and what you are required to do about the malfunction. You will also be given information on how to care for the various pieces of equipment you have in your clinic, such as operational checks and inspections.

Any major maintenance will be performed by a qualified medical maintenance repairman or by representatives from the commercial firm that manufactures the equipment. You are NOT a qualified maintenance repairman. Air Force Regulation 66-22 and its changes will tell you exactly what the responsibilities and procedures are for maintaining medical equipment. It states that the only qualified repairmen are graduates from the medical maintenance course at St. Louis Medical Depot, or civilians with equivalent training. The importance of understanding where you stand, in regard to maintenance, cannot be over emphasized. Performing any maintenance that is not specifically authorized may cost you some of your hard earned pay. Whenever you find need for maintenance you should immediately check with medical supply, or with the medical maintenance repairmen in your hospital, for instructions on how to have your equipment repaired. If you are ever doubtful of the type of maintenance you are allowed to perform, check before you attempt to do anything.

The information that is given in this chapter is not specific, but general. It will tell you some of the things you are expected to do. The various malfunctions are given so that you may have some understanding of what might be wrong so you can describe the symptoms to your repairman and he will have an idea of where to start looking.

To help you to become familiar with the various types of X-ray machines and accessories which you may have to work with or possibly order for your clinic, there has been prepared a partial listing of the more commonly used items. This listing contained at the back of this chapter provides the stock number and nomenclature of

the item, its approximate cost, the power required, probably spare parts, kind of lubrication and the location of the equipment.

## OPERATION AND INSPECTION

There are many types of machines and accessories in use throughout the Air Force. You may have several different types or just one in your clinic. All equipment requires periodic inspection, and preventative maintenance checks. You should study and become thoroughly familiar with the operation and inspection check lists contained in this section.

## MACHINES

OPERATIONAL CHECKS. Each machine needs to be checked for proper operation at specific times. The following material shows what to do and when to do it.

| | |
|---|---|
| ● Energize the unit and determine when possible, if the filaments of valve and X-ray tubes are heated, before making exposures. | Daily |
| ● Determine that the rotating anode revolves and there is time delay before the contactor closes. | Daily |
| ● Protect fluorescent screen from direct radiation by placing shield over the screen. | Always |
| ● Operate the unit on radiography by using the safety-timer. Make some exposures using various techniques. Your MA meter should correspond with selected MA at any KVP. Meter readings should remain constant during exposure and be consistent at repeated exposures using the same techniques. | Daily |
| ● Check high voltage circuit for insulation breakdown and connection failures by operating the unit at maximum KVP and low MA setting. There should be no crackling, sputtering or hissing within the X-ray tube head, high voltage cables or transformer. | Daily |
| ● Photofluorographic machine: It should be impossible to make an exposure with no card in the photofilm identifier, no film in the camera, or with the camera locked in position. Attempt exposure to prove this. | Daily |
| ● Photofluorographic machine: Check photo-timer for proper operation. With the film in the camera and a card in the photo-film identifier, make several | |

exposures. The camera should advance the film one frame at each exposure and lock properly. — Daily

- Photofluorographic machine: The tube arm and hood assembly should be properly raised and lowered throughout the entire range by either the motor or the handcrank. — Daily
- The kilovolt selector should control the KVP over the full range of the voltmeter. — Daily
- 15 MA Portable: Operate the unit on radiographic position at 85 KVP. The MA should be maintained at 15 MA to within plus or minus 5%. Meter readings should remain constant during exposure and should be consistent on repeated exposures. — Daily
- The fluoroscopic screen should be free of blemishes and when exposed to radiation, should be evenly illuminated. — Always
- The fluoroscopic shutters should operate smoothly and permit adjustment of the illuminated field to any size within the area of the fluoroscopic screen. — Always
- Check the radiographic timer at 1/10 second with spin top. The timer should be accurate within plus or minus 5%. — Monthly
- The center of the illuminated field should coincide with that of the fluoroscopic screen. — Always
- Turn the technique selector to any radiographic position and put the bucky switch into the IN position. Press the exposure switch. The bucky grid should start reciprocating and the timer circuit should be energized. The bucky grid should continue to reciprocate until the exposure switch is released. — Daily
- Check the table tilting mechanism. The table should tilt 10 degrees Trendelenburg to the vertical position. It should be impossible to tilt the table with the spot film device (GE 100 MA) in the parked position. The operation should be quiet, smooth, without vibration or jerky starts or stops. When the power is released, the table should stop smoothly and without coasting. — Daily
- Turn the selector switch to fluoroscopic position. The highest MA you should be able to read is 5 MA. — Daily

| | |
|---|---|
| ● Redline the voltmeter before each exposure and at beginning of each day. | Always |
| ● CAUTION: Do not make an exposure if the X-ray tube filament is inoperative. | Never |
| ● Adjust the MA meter from low value to desired value. | Always |
| ● Make sure that the KVP minor and major selectors are on contact and not between contacts. | Always |
| ● Allow your unit to warm up properly. | Always |
| ● Observe all meters during operation for indication of malfunctions. | Always |
| ● Know the capacity of your unit before you operate it and remain within the prescribed limits as shown by your tube rating chart. | Always |

INSPECTIONS. Much of your maintenance trouble can be avoided if you will spend a few moments just looking your equipment over. Inspections are necessary to keep some small thing from developing into a major and costly repair job.

| WHAT TO LOOK FOR | WHEN TO DO IT |
|---|---|
| ● Switches, controls, relays and motors should function properly. | Daily |
| ● The timer should be accurate within 5% of any setting. | Daily |
| ● All mountings should be secure and free from dust, rust and corrosion. | Daily |
| ● There should be no evidence of cracks or oil leaks in the tube heads or transformers. | Daily |
| ● All terminals, studs, and connections should be secure and free from corrosion. | Daily |
| ● Cable receptacles and cables should be free of cracks and burns. | Daily |
| ● The insulating oil should be clean with no evidence of dust, lint or carbonized particles floating in it. | Daily |
| ● The chains or cables connecting the hood of a photofluorographic machine, and its tube arm, should have no kinks and show no sign of excessive wear. | Daily |

| | |
|---|---|
| ● If you have a transparent radiation port, check it to see that there are no air bubbles within the tube head, that the tube is not gassy and that the target is free from cracks or punctures. | Daily |
| ● Check your rotating anode and blower motors to see if they run smoothly and without excessive vibration. | Daily |
| ● Interconnecting line cables and shockproof cables should be complete with connectors or lugs and of sufficient length to permit required movements for which the unit was designed and show no signs of excessive wear. | Daily |
| ● The table counterbalance mechanism should function properly. | Daily |
| ● Table top should lock in either the horizontal or vertical position. | Daily |
| ● Table tops should not be warped or cracked. | Daily |
| ● The component parts of the table should not be bent or cracked and show no signs of rust or corrosion. | Daily |
| ● The vertical stereo-shift should be positive in its action and should bring the tube to rest without excessive vibration. | Daily |
| ● Tube carriage and spot film device should be properly counterbalanced. | Daily |
| ● Bucky carriage should be easily moved and should lock automatically upon the release of the hand crank or button. | Daily |
| ● Spot film cassette carriage should operate properly so that all the required positions of the cassette can be easily obtained. | Daily |
| ● The tube carriage assembly should move easily and firmly to positions without straining or kinking shockproof cables. | Daily |
| ● Check the hydraulic system on the table. The fluid should be 1-1/2 to 2 inches from the top of the tank. There should be no evidence of leaks in the tank, pump, valve, hose or cylinder. | Daily |
| ● Do not allow the tube head to be banged against | |

| | |
|---|---|
| the wall or spot-film device. | Never |
| ● Do not go inside the control, tube or transformer to attempt to make adjustments. Call on maintenance men. | |
| ● Lubricate the table motor with medium oil. | Monthly |
| ● Check the table gears and bearings for lubrication. | Quarterly |
| ● Use a slightly oily rag on all rails, slides or tracks for cleaning and lubrication. | Daily |
| ● If the table is hydraulically operated NEVER USE CARBON TETRACHLORIDE to clean the pump piston shaft. | Never |
| ● Use graphite to lubricate the pump piston shaft. | As needed |
| ● Use #18 Stanoil in the hydraulic system. | Always |
| ● Lightly coat edges of each shutter blade on the fluoroscopy carriage with vasoline. | Quarterly |
| ● Do not pound on the meters and indicators of the unit. | Never |
| ● Do not tamper with the settings of the density control on the phototimer of a photofluorographic machine. | Never |
| ● CAUTION: When replacing or repairing parts of the unit, always be sure that the MAIN POWER SOURCE IS DISCONNECTED. | |

## ACCESSORY EQUIPMENT

Although most of the other equipment you need to do your work is comparatively less costly than the machines, you should practice care in using it. The articles listed below are essential tools in your job and should be kept in good working condition.

INSPECTION AND HANDLING OF MISCELLANEOUS ITEMS. The items discussed below are to be considered in the inspection and handling of accessory equipment.

- Aprons should be checked for cracks or leaks by X-raying suspected spots. Aprons should be rolled or hung up so that there are no sharp folds.

- Gloves should be placed in such a manner that perspiration will dry out.

This can be over a can or mock wooden hand. Check for cracks and leaks by X-raying the gloves.

- Calipers should never be bent or thrown about. Accuracy can be checked by placing rule against a true vertical surface. If bent, straighten caliper until it touches surface of vertical board.

- Wafer type grids must be handled with care. Do not throw, bend or pack between cassettes. Also do not use a large grid on a small cassette if a patient must lie on it. The edges will overlap and the grid will either crack or warp.

- Hangers should be checked so the film is taut and does not bulge. The clips should be kept clean. Films should be removed individually.

- Equipment should be stored in such a place, and manner as to allow the least possible damage. The equipment should be kept clean.

## DOSIMETERS

The various type dosimeters or ion chambers that are in use for therapy units must be handled with extreme care. They are delicate precision instruments and cannot stand abuse of any kind.

- The unit should not be opened at any time for internal adjustment. When unit is not working properly it should be returned to medical supply for repair or replacement.

## CASSETTE CHANGERS

There are different types of electrically controlled cassette changers, but the care of all of them is similar.

### OPERATIONAL CHECKS.

- Shift cassettes by either the manual or electrical control. The shifting, with any two cassettes, should be accomplished in 2 seconds and there should be no residual vibration at the end of the shift.

- Each cassette should stop in the same position with respect to the exposure panel for receiving radiation.

- The cassette carriage assembly should be easily raised or lowered throughout its entire range of travel.

### INSPECTIONS.

- Counterweights should be of correct size and securely suspended while cables and chains should be free of kinks and excessive wear.

- All mountings should be secure.

- Cassette carriages should hold any standard cassette, in both vertical and horizontal positions. The cassettes should be firmly held in place and yet be removed easily.

- Switches, solenoids, motor, brakes, locking devices, and spring bumpers should function properly.

- Direct radiation should not reach the cassettes when they are not in the exposure position.

- Do not force the changing mechanism.

- Lubricate the bearings and gears.

- Lubricate and clean the rails, tracks and slides by using a slightly oily rag.

## X-RAY ILLUMINATOR

The unit should provide sufficient light to properly illuminate radiographs of normal density. The following are inspection items.

- There should be no cracks or broken parts in the glass.

- The switch, lamps, lamp holders, starters and cord with connector plug should be secure and in good condition.

ELECTRIC FLUID MIXER. The following are inspection items.

- After using unit and accessories be sure to clean and dry before storing.

- The cord should be of sufficient length and complete with plug connector in good condition.

STEREOSCOPE. The following are inspection items.

- All moving parts should operate smoothly and firmly.

- All mountings should be secure.

- There should be no cracked, broken or bent parts.

- Cord, switches, lamps, viewing screens, curtains, reflectors, mirror assembly, etc. should be in good condition.

## DARKROOM EQUIPMENT

The darkroom is an area which requires good maintenance and care. This equipment is more exposed to the dangers of rust and corrosion than other equipment

in the clinic. The equipment is moderately expensive and can be kept in proper order for longer periods if good maintenance is performed daily.

## PROCESSING TANK

OPERATIONAL CHECKS. The following procedures are followed in operational checks.

- Photofluorographic developing tank units should transfer a 100 foot roll of 70 mm. film from one reel to the other and then the motor should reverse automatically to drive the film in the opposite direction. This cycle should be continued throughout the developing, fixing, and washing sequence.
- For master or refrigerated units turn on the water supply to the unit. The water flow should be approximately 1 gallon every 3 minutes.
- For master and refrigerator units turn the compressor switch to ON position. The compressor should start operating immediately and smoothly.
- The water temperature in the wash compartment should be reduced to 68 degrees plus or minus 2 degrees and be maintained at that temperature.
- Timer should be accurate within 2% of any setting.
- Illuminator should provide proper illumination of radiographs.
- All motors, compressors and pumps should operate smoothly.

INSPECTIONS. Frequent inspections of this equipment are important for proper maintenance.

- All component parts should be free from rust and corrosion.
- Tanks should not leak and plumbing should show no signs of leakage. Call AIO on plumbing and any valve that may show signs of leaking.
- Cables should be of sufficient length, complete with plug connector, and in good condition.
- All valves and regulators should function properly.
- Switches, timer, safelights, illuminator, thermometer, vacuum breakers, etc. should operate correctly and be in good condition.
- Keep the fluids at the correct level.
- Never allow debris to collect in the fluids. A fine kitchen strainer can be of help in removing debris.
- Clean the filter screens.

- Change the water in the tanks. Clean, scrub, and rinse the tanks thoroughly before refilling.

- Tighten a leaking packing gland only until the leak stops.

- Wipe condensation and drippings from the unit with a slightly oily rag.

- Keep the condenser radiator clean.

## COOLING AND DRYING EQUIPMENT

OPERATIONAL CHECKS. These procedures are followed when inspecting X-ray processing coolers and heaters.

- Turn the fan motor switch to ON. Fan motor should run smoothly and without excessive vibration.

- Turn the heater switch to ON. Heating elements should become warm immediately.

- Turn fan motor switch to OFF. Fan motor should stop and the heating elements should be de-energized even though the heater switch is still ON.

- The dryer, if operating correctly, should dry films in 45 minutes.

INSPECTIONS.

- All mountings should be secure.

- Film drying drawers should move freely.

- Drip pans, drawers and hanger racks should be free of dust and corrosion.

- Line cord, connector and all wiring should be secure and in good condition.

- Unexposed film compartment should be light tight.

- Switches, heating elements, fuse block, door, drawers and linoleum table top should be in good condition.

You have now become familiar with the various things that you can check each day. The operational checks and the inspections are a continuing job for you. When you find areas which require attention, make immediate note of such areas and get them fixed, replaced or adjusted as soon as possible. You may find instances where your supply or repairman will take more than the usual time to attend to your maintenance problems. Keep a check on the time between the time of request and completion of repairs. Follow up your request until the work is accomplished. If there are instances which call for seeing your medical supply officer or your radiologist to get matters attended to - do it! You have no excuse for letting equipment become dangerous, or operating it in conditions which cause it to depreciate long before its value has been received. However, allow sufficient leeway for genuine supply or maintenance difficulties.

## MAINTENANCE AND INSPECTION CONTRACTS

Many clinics do not have a regularly assigned medical maintenance repairman. To provide proper maintenance for the equipment, a contract is made with commercial firms that manufacture the equipment. These contracts will state the type of inspection and maintenance that is to be done, when this work will be performed, and the cost. The cost will be a part of your budgeting if you need contract maintenance. You will go to your medical supply and arrange these maintenance contracts. They will do all of the necessary paper work. You will be required to provide a certificate each time a commercial maintenance man works on equipment. This certificate will certify that the actual maintenance was performed and identify the equipment on which the maintenance was done. AFR 70-16 and its changes provide the authorization for this type of contract. Paragraph 14e of this regulation requires that you return any X-ray tubes that have been damaged to the medical supply so that a trade-in value can be obtained.

## TROUBLE ANALYSIS

Even with continual operational checks and inspections you will find that some of your equipment will require repair or replacement. Although you are not a qualified specialist in the maintenance of your equipment, you should be familiar with some of the troubles that you may encounter. To be able to inform your maintenance man how a machine is acting will help him to determine the reasons for the failure.

Here, again, this manual cannot be too specific. It will give general information on a few of the more common troubles with all machines. The exact cause of malfunctions in your particular machine will be peculiar to its construction and design. The main thing to keep in mind is to be certain to have your unit checked whenever you encounter trouble. Do not attempt to adjust or repair it yourself except possibly to change a fuse or a lamp. Even this could be detrimental as there may be a deeper cause hidden behind a blown fuse.

You will be given a few of the various parts that you will notice malfunctions on, a brief analysis of the trouble and the possible cause of the trouble.

## OVERALL UNIT FAILURE

When the unit does not operate at all, or the KVP and filament meter on field machines do not indicate, you have open, loose or shorted connections. This is a very common malfunction and it is solved in many instances by checking the main switch box, by turning on the machine at its own switch, by resetting the circuit breaker or thermosafety plug, or checking fuses. You may also be in between the contacts on the KVP selector so you can turn your KVP knob and see if that is a cause. You can usually feel the contacts when they are moved into place. If none of this helps, you may check the fuses in the building that supply your machine. Do these things first before you call your maintenance man. It may save you some embarrassment and, if you are on contract maintenance, a great deal of expense. If the cause cannot be found by doing these things then call your maintenance man to check your unit. You may have corroded or defective contactors. He will be able to find loose or more

serious types of shorts in your circuits.

## CONTACTORS FAIL TO CLOSE

If you do not hear your machine click when you make an exposure, even when everything is on and working properly, your contactors have not closed. The contactors are the devices which complete your circuits. A number of things could be wrong and you should check each of them.

- Hand timers: Your plug may be loose from the connection.
- Other timers: You may have failed to set them.
- Radiographic-Fluoroscopic switch: Be sure that you have them set for the procedure you are doing.
- Circuit breakers: These may be checked and reset.
- Hand-Foot timers: Check to see that you have the proper timer in the circuit.

Other causes may be the failure of relay contacts or the main contactor in your machine. These will require the attention of your maintenance man.

## MILLIAMETER

Milliameters sometimes fail to register, show excessive MA, or fluctuate. Just because the meter does not show that X-rays are being produced, don't assume that they aren't. You can check whether the tube is producing or not by placing it over the fluoroscopic screen. If they are being produced, you have a short in the meter and the current is by passing it. The milliameter may be defective and need replacing, or various rectifiers, contactors or cable wires may be defective.

Excessive MA may be produced when the X-ray tube is gassy. Also the filament rheostat may need adjustment or replacement. Excessive MA in both tubes of a double tube unit may be caused by a defective voltage regulator.

Low MA may be the fault of a defective voltage regulator. It may also be caused by a filament in a Kenetron tube being burned out, making the unit operate on half-wave rectification when it should be working on full-wave. There may also be poor connections in the filament circuit. Poor connections may be in the control panel, control to transformer cable, or in the transformer itself.

Inconsistent or fluctuating MA can be caused by a gassy X-ray tube. There can also be insulation failures in the cables, the transformer oil or gas. Insulation failures may be discovered by appearance of arcing, or cracking sound. Whenever you see or hear this, do not get within 12 feet of the cable. Insulation failure can be suspected if you hear a cracking sound from your transformer, see smoke seeping, or detect any odor of carbonization.

## VOLTMETER

The voltmeter sometimes will not register. This may be caused by a defective voltmeter, burned fuse or contacts improperly placed. There may be poor contact or the main line cable may be broken, or some internal contactors may not be closed.

## CIRCUIT BREAKERS

When your circuit breaker keeps popping out, you may have a number of causes for it. The transformer gas or oil may be contaminated. A cracking noise will give you a clue to this. The X-ray tube may be gassy or have a leak. If your tube has a cracking or buzzing sound, you may have an internal short to ground from your tube. Your high voltage cable may be defective. A Kenetron tube may be gassy or the primary circuit to the high tension transformer may be grounded.

## X-RAY TUBES

X-ray tubes should be operated within the ratings given in the tube rating charts. When this is done your tube will have longer life and give you less trouble. An X-ray tube that is heard to crack has something definitely wrong with it. The tube may be gassy. The insulation oil may have a low insulating strength as the tube grows older through use. There may even be insufficient oil in the tube housing. The tube may leak and have air or there could be foreign particles in the tube.

A tube filament can cause an open circuit. The filament may be burned out because of normal use. There may be loose connections in the tube casing or there might be some foreign particles in the tube which is shorting the filament.

A rotating anode may not rotate in a tube. This may be caused by broken leads to the stator cable, poor contact at terminals, or particles inside the tube which block its rotation.

## TABLES

There are times when a table won't tilt or move when you want it to. Generally, this can be solved by checking the operating procedure necessary to get it to move. Your spot film device may not be extended out (100 MA, General Electric). The connections to your table may be loose or faulty. The control stand may have a burned out fuse in it. The microswitches on the foot pedals could be defective. Or your motor to the table could be burned out. Also the fluid in your hydraulic tank may be low. This should be filled to about 1-1/2 to 2 inches from the top with #18 Stanoil.

The screen carriage may be hard to move about. Be sure that your table locks are loosened. Do not tighten the locks too tight or turn them until they come out. The same care should be taken with the tube carriage locks. If the fluoroscopic carriage floats up and down when the table is vertical, your counterweights behind the table top should be adjusted with the proper weights.

If the bucky grid doesn't work properly, the cable should be checked to see that it is connected. Check your control panel to see if the switch is in the proper place.

If none of these are the cause you may have a defective microswitch in the mechanism.

## BEHIND AND AHEAD

You have some knowledge now of what it takes to maintain your equipment and a few of the more common malfunctions that you may meet. The care which you provide your equipment will determine the efficiency you can have in your department. A patient isn't worried about the inability of your equipment to operate, or if it operates badly. He is only interested in his broken leg. Maintain your equipment and repair it as quickly as malfunctions are noted and you will find no need for excuses or failures.

Ahead of you is a chapter on the administration you will find in the X-ray clinic. You will learn about forms, reports, correspondence and files. Because administration is an everyday job you should be thoroughly familiar with as many aspects of it as you can.

## MACHINES

| Stock Number and Nomenclature | Approx Cost | Power | Probable Spare Parts | Lubricant | Location |
|---|---|---|---|---|---|
| 6525-612-0890 X-ray Apparatus Photofluorographic | $7316 | 200 MA 200 V 60 cyc AC | Rotating Anode Tube, Fuses, Lamps, Cables | Med. Oil Vasoline | Flt. Surgeon |
| 6525-612-4720 X-ray Apparatus, Radiographic and Fluoroscopic, Med. | $7026 | 100 MA 110-220 V 60 cyc AC | " | " | X-ray Clinic |
| 6525-612-4853 X-ray Apparatus, Radiographic and Fluoroscopic, Lge. | $7038 | 200 MA 220 V 60 cyc AC | " | " | " |
| 6525-612-4881 X-ray Apparatus, Radiographic and Medical | $12155 | 300 MA 220 V 60 cyc AC | " | " | " |
| 6525-612-5200 X-ray Apparatus, Radiographic, Med. Mobile Portable | $2271 | 110 V 60 cyc AC 15 MA | Fuses, Lamps, Hand Timer, Timer Cord | " | " |

MACHINES (Con't)

| Stock Number and Nomenclature | Approx Cost | Power | Probable Spare Parts | Lubricant | Location |
|---|---|---|---|---|---|
| 6526-612-5325 X-ray Apparatus, Radiographic, Medical, Mobile, Portable | $ 663 | 110 V 60 cyc AC 30 MA | Fuses, Lamps, Hand Timer, Timer Cord | Med. Oil Vasoline | X-ray Clinic |
| 6525-616-7800 X-ray Apparatus, Therapeutic | $3966 | 220 V 60 cyc AC 140 KVP | Fuses, Lamps | " | " |
| 6525-616-7810 X-ray Apparatus, Therapeutic | $11276 | 220 V 60 cyc AC 250 KVP | " | " | " |

ACCESSORY EQUIPMENT

| Stock Number and Nomenclature | Approx Cost | Power | Probable Spare Parts | Lubricant | Location |
|---|---|---|---|---|---|
| 8415-600-2000 Apron, X-ray, Protective, Lead Impregnated | $ 12 | | | | X-ray Clinic |
| 6525-600-7900 Caliper, X-ray Technique | $ 2 | | | | " |
| 8415-603-0010 Gloves, X-ray Protective, Lead Impreg-nated | $ 15 | | | | " |
| 6525-603-1300 Grid, X-ray Apparatus Straight Wafer Type, 14" x 17" | $ 223 | | | | " |
| 6525-603-1500 Grid, X-ray Apparatus, Curved Wafer Type 14" x 17" | $ 97 | | | | " |
| 6525-603-1750 Hanger, X-ray Film Processing, | | (con't next | page) | | |

## ACCESSORY EQUIPMENT (Con't)

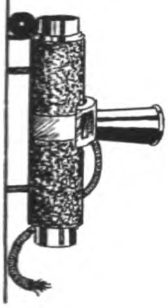
| Stock Number and Nomenclature | Approx Cost | Power | Probable Spare Parts | Lubricant | Location |
|---|---|---|---|---|---|
| Assorted sizes, 4" x 10" to 14" x 17" | $ 10 | | | | X-ray Clinic |
| 6525-605-0000 Locator, Radiographic Ocular, Foreign Body Sweet's | $ 152 | | | | " |
| 6665-612-6500 Radiac Set, R-Meter, Dosimeter | $ 362 | | | | " |
| 6525-610-1700 Cassette Changer | $ 760 | 110 V 60 cyc AC | | Med. Oil | " |
| 6525-604-0000 Illuminator, X-ray | $ 13 | 110 V 60 cyc AC | Lamps, Frosted Glass | | " |
| 7320-610-9800 Mixer, Fluid, Electric | $ 25 | 110 V 60 cyc AC | | | " |
| 6525-613-6000 Stereoscope, X-ray film, Mounted Fluorescent | $ 438 | 110 V 60 cyc AC | Lamps | | " |

## DARKROOM EQUIPMENT

| Stock Number and Nomenclature | Approx Cost | Power | Probable Spare Parts | Lubricant | Location |
|---|---|---|---|---|---|
| 6525-616-7300 Processing Unit, X-ray Film, 3 Tanks | $ 780 | 110 V 60 cyc AC | | | |
| 6525-616-7678 Tank, Master, X-ray Film Processing, 3 Tanks | $ 240 | " | | | |
| 6525-604-2110 | | (con't next page) | | | |

## DARKROOM EQUIPMENT (Con't)

| Stock Number and Nomenclature | Approx Cost | Power | Probable Spare Parts | Lubricant | Location |
|---|---|---|---|---|---|
| Tank, Insert, 20 Gal. | $ 28 | | | | |
| 6525-612-4400 Processing Machine Photographic Film | $ 142 | 110 V 60 cyc AC | | | |
| 6525-629-0000 Cooler and heater, X-ray Film Processing Apparatus | $ 730 | 110 V 60 cyc AC | | | X-ray Sec. Field Unit |
| 6740-601-4390 Dryer, Photographic Film | $ 100 | AC 110 V 60 cyc | Lamps | Med. Oil | |
| 6525-601-4280 Dryer and Bin, X-ray Film | $ 340 | " | Vents Right or Left | " | |
| 6525-601-4500 Dryer, X-ray Film | $ 226 | " | None | " | |



# CHAPTER 13

## DEPARTMENT ADMINISTRATION

YOU will be required to perform some administration in any clinic to which you are assigned. You will write letters, receive letters asking information, keep logs and schedules of patients who have been examined in your clinic, make reports of various kinds and file them. Every individual unit in the Air Force has some administration to perform. Good administration can be yours if you are conscientious in your record and filing procedures. If you're not, you will be creating a future hardship on an individual who is depending on you for information which he may need.

In an X-ray clinic you will have a number of different forms and reports to check, prepare and file. Each one of these forms and reports is completed for each patient X-rayed. They are made to request examinations, show what examinations were performed and the results of these examinations. With the reports and the films of your patient filed properly, your patient can be assured that if he ever needs them for future use they will be readily available.

You will also need forms and records for needed supplies, repairs on your clinic, and personnel records. To prepare budget estimates, your command or hospital may need information on how much money it will cost you to run your section. So as you see you will be part executive and part technician in many instances. As you proceed up the career ladder you will be doing more and more administration. The important thing to remember is that you can do your job poorly and create confusion or you can do it well. The administration of your department reflects directly upon your ability to operate a good reliable clinic.

### DEPARTMENT ETHICS

Before you can begin to function as a technician or as an administrator you must be aware of proper ethics. Ethics are the characteristics or manners you use when dealing with patients, professional people or your fellow technicians. To write and read about ethics is easy ..... to develop ethics may take a little longer. Many people do not understand medical ethics and their effect on patient recovery. When

we are criticized we instantly feel the necessity to defend our actions. If your NCOIC or your radiologist told you that you are not studying this manual correctly you might experience immediate anger. Your next reaction might be to ask why you weren't studying right. What does this have to do with ethics?

Because you are in a profession dealing with sick people, you must fully and COMPLETELY understand that these people are not always at their best mentally. They are nervous, frightened and physically below par. They become easily irritated, demanding and sarcastic. Each individual wants immediate attention to his particular problem. What may seem to appear minor or petty to you may loom as a great problem to your patient. Each of us has this emotional characteristic of bristling with righteous anger when someone reprimands us without justification. Your patients may belittle your earnest efforts and be unappreciative of your attention to their welfare, so you must learn to CONTROL YOUR OWN EMOTIONS. You will meet all matters calmly, sympathetically and with utmost patience. It will take time and effort on your part to learn how to do this in all cases. You will be learning to handle people...... a task which is a constant challenge. Yours will be a more perplexing problem because your people will be ill and frightened.

You must develop a considerate attitude whether you are working with a tragically broken crash victim, a suffering cancer patient, or the fellow who must have a chest film for a flying physical. Your attitude, whether you know it or not, is read by your patient.

It is frequently difficult to determine the thin line which separates what to do in one case over what you did in another. You may easily find the right answer or you may slip, but with practice and training you can meet most situations sensibly. We can give you printed ethics but the real ethical touch will be developed only with practice.

## THE PATIENT AND YOU

You should be friendly and courteous. This will help you to gain the patient's confidence. Learn your patient's name. Show an interest in his illness. He will want to talk about his condition so don't appear bored. Your patient will want to relate his experiences to you and if you show disbelief, you will lose his confidence. Many patients will try to pump you for information. Do not give any information without permission of the doctor. You are not to diagnose or relate your opinion as to the accuracy of a diagnosis. You must appear calm at all times. A patient seeing an obviously nervous and insecure technician working on him will have doubts about the care he is receiving. You should keep to yourself every confidence that your patient cares to relate to you. You will not discuss subjects which obviously irritate your patient. Try to keep the patient's mind on pleasant subjects. You will practice professional blindness in the matter of sex. You will remember that this was discussed in detail in Chapter 7. This is important in both the legal and moral sense. A disturbed or embarrassed patient can be an uncooperative patient. You will never reveal disgust, distaste, surprise or horror at your patient's appearance or condition. You must control any anger or impatience that you may feel and not let it show in your face or manner. If your patient leaves you feeling better, you have practiced good ethics.

## DOCTORS AND YOU

You will be working under the direction of a physician or a nurse in many situations. What type of relation must you establish with these people to help your patient recover? As you know, the doctor is the man with the knowledge and ability. You must first realize that he has more knowledge than you do. You must accept this as a fact. You will not question, relate your opinion, or advise your doctor on what he should do about a diagnosis or treatment.

You will PERFORM EXACTLY what the doctor orders. When this is not possible, and there might be instances, you will inform him immediately and state the reasons. He may be able to suggest ways of following his request or devise a new means for accomplishing what he needs. You will, however, make every effort possible to do what he asks of you. You must be completely honest and inform your doctor when mistakes occur. You must clearly understand the directions he gives; ask him about any point that is confusing to you. Don't let gruffness scare you. Most physicians have much on their minds and they may appear detached at times.

You will treat the doctor with respect at all times. In the presence of patients you will remain in the background and assist him quietly. Attempt to learn your doctor's methods and techniques so that you can anticipate his needs. You will never discuss the doctor in a negative manner.

## OTHER TECHNICIANS AND YOU

It is difficult to maintain the correct ethical relationship with other technicians. With the patient and the doctor you have a rather impersonal relationship, but with other technicians you are on a basis of close working relationship. Just what ethical relationship must exist between you and other technicians?

Probably the most important thing is to do your SHARE of the work. Although some technicians are more experienced, you should perform anything assigned to you. If there are periods when your help could be used by others, it should be given. Each technician should see that no patient is kept waiting when he can perform the examination requested. The technician should never argue over methods or results of an examination in the presence of a patient. There should be no appearance of friction or animosity in a clinic when patients are present.

You should do each task assigned to you completely and as well as you can. Tasks that have been left undone or done poorly will cause another technician added work that is not necessary. It will slow the work in your clinic, create confusion and friction and lower the morale of your clinic. Low morale influences the treatment that a patient receives.

When differences of opinion are made known, a mature approach should be used in solving these differences. Discuss the problem quietly and attempt to remove emotionalism that may be involved. Once the problem is settled you will accept the decision given willingly. It is a small boy indeed who picks up the ball and goes home because somebody won't play by the rules.

Be courteous to everyone. Friendliness and enthusiasm generate friendliness and enthusiasm in others. Be pleasant even when it is an effort. Cooperate with the

others on an unpleasant task, unexpected rushes or workloads. Help others to learn new procedures.

The ethics that are practiced among the technicians themselves will be a predominant factor in their relations with their doctors and their patients.

## PROCESSING YOUR PATIENT

The type of duties you will perform will depend upon the size of your hospital and clinic. If your duty is receptionist, your appearance and manner will give the patient his first impression of your clinic. After greeting your patient, accept from him his request form and record the information you need for your records. He will then be scheduled according to the examination he will receive.

### SCHEDULING

The clinic must have a scheduling system. You must have certain times set aside for the various types of patients and examinations. When scheduling you must consider how many rooms you have available, how long these rooms will be occupied, what equipment will be available in each room, who is experienced in the examination, etc. For example, an IVP can take up a room for approximately forty minutes. Arrange your schedule so that three or four people are not scheduled for the same hour because one of them may have to wait four hours. A crowded waiting room should be avoided if possible.

For many routine examinations coming from sick call or the flight surgeon's office, you will be able to maintain a schedule so that most of the examinations can be carried out in one particular room. Some clinics, with sufficient space, machines and personnel, will have a separate room for chest work, skull work, long bones, etc. This will not mean that each person will have a definite appointment but that these routine examinations can be performed within certain hours.

Scheduling will vary according to the type of clinic you are operating. A small clinic can, and often does, work on a first come first served basis. A larger clinic, with a number of special procedures to be done, will need a regulated schedule.

You will need separate schedules for routine work, special procedures and therapy treatments. Sometimes these are kept at the main reception desk, but some clinics will have each separate section schedule the examinations. Generally, the special procedures will be scheduled in the mornings because of food and fluid restrictions, and your therapy procedures in the afternoon.

You must determine how much time will be required for each examination, keeping in mind that a GI series has a repeat film five hours after the examination, etc. You will need to remember also the order in which you will schedule several examinations on one patient, such as doing the gall bladder examination before a GI series.

An important thing to remember when scheduling patients with contagious di-

sease is to keep them from contact with any other personnel. They are kept in the wards until you are definitely ready for them. They are brought directly to the clinic, examined and returned with as little contact with others as possible. You should never have them waiting in the hall or waiting room.

The variety of circumstances makes it difficult to state a definite procedure. It is important that you utilize your personnel, equipment and time as efficiently as possible. Serve your patient so pleasantly and quickly that he will feel that he has been cared for individually.

## REQUEST FORM

The patient will give you Standard Form 519-A, "Radiographic Report." It is a duplicate form which contains a carbon insert. This, if signed by a physician or in the name of a physician requesting the examination, is the authority to perform the procedures requested. This form is both a request for the examination and a report form. You will see that it will show the name, rank, serial number, hospital register number for inpatients, age, sex, ward number, patient status (bed, wheelchair, ambulatory, etc.), examination requested, doctor requesting examination, date of request, a brief clinical history, space for film identification number, date of report, brief radiographic report, signature of radiologist reporting and the name of the installation making the report.

Spaces which should be checked for specific information are age, ward number or requesting agency, and the clinical history. These three areas are where the most errors occur. The age helps in the diagnosis; the name of the requesting agency is necessary in returning reports; and the brief clinical history is an aid to diagnosis as it gives the radiologist a clue as to what to look for in the film. Also on some physical examinations you will indicate on the form the height and weight of the individual. Some doctors will also include the views that they wish to have taken on the form in the "Examination Requested" space.

Make sure the report is legible and distinct both on the original and the carbon copy. If they are not clear, you will have difficulty in filing your reports and identifying them properly.

After you have checked the form and obtained any additional information that is necessary, you are ready to place an identification number on the request form in the "Film Number" space.

## DAILY LOG BOOK

The daily log book is used to record the identification number assigned to your patient. You will ask him if he has ever been X-rayed in your clinic before. If he hasn't you will take the next new number from your log book and assign it to his request form. If he has been X-rayed before in your clinic you will look through your files of index cards or report envelopes and get his old number and place it on the request form.

ONE ID NUMBER. There are a number of methods used to assign identification numbers. One method is to assign each patient ONLY ONE number per year. No

matter how many times a year a patient is examined, all of his films will bear the same number. For example, John Doe was X-rayed for the first time on 5 Jan 57. He was assigned the number "10" from the log book. After that date, John was X-rayed on 2 Mar 57, 31 July 57, and 12 Oct 57. Each time he came in he was given the film identification number "10". This number will be on all of his films for the year.

NEW ID NUMBER FOR EVERY EXAMINATION. The other method used in some clinics is assigning a new number from the log book EACH TIME the patient is examined. Each time he receives a new number all the previous films and reports are brought forward and placed with the films and reports of the new number.

Regardless of the method used, the numbers are recorded in the daily log book. This log is usually started at the first of the year with the number 1 and numbered consecutively. It will contain information on the film number, the name of the patient, his rank, serial number, who ordered the films, the part, the address and phone number of the patient's organization or home. Other information can be included that is pertinent to individual clinics.

WHERE DO YOU FIND OLD NUMBERS? Each clinic will maintain some type of cross index file. These files may be 3 x 5 index cards with the necessary information noted on them or they may be report holders with the information on the outside of the jacket. These indexes are alphabetically arranged. The name of the patient, rank, AFSN, date of examination, part and film number are placed on these index cards or report holders. When John comes in again you can look in your file and find his name on the index card and his old number and put this on the request form as his identification number.

Chapter 8, Section III, AFM 160-20, is a guide for setting up these various numbering systems. The size of your clinic and its workload will determine the most feasible method to use.

Once the number is assigned, the request form is given to the technician who will do the examination. He will place that number on all of the films that he takes of that patient. In some clinics he will write on the back of the request the sizes of films he used and the number of each size he used. By doing this he will show how many films belong to each examination. If he takes three 10 x 12's and only finds two when he is ready to match request and films, then he knows there is one film missing and will look for it.

## WHERE DOES THE REQUEST GO AFTER THE EXAMINATION?

When the examination has been completed the technician will match the processed films to the requests.

Each film is placed in a negative preserver. These preservers are paper envelopes measuring 14-1/2 x 17-1/2 inches. There is a small size that is used for smaller photofluorographic films.

A film preserver is made up from the request for patients who have never been X-rayed in your department before. From the request you will put the film number, the name, rank, AFSN, date of examination, part examined and the number of films

on the preserver. You may also put such information as the positions used or whether there are stereo films, etc., as shown below.

| | | |
|---|---|---|
| Name: | JOHN DOES | |
| Rank: | A/1C | AF 12272150 |
| Film: | 10 | |

5 Jan 57 - Chest - 3 - Stereo PA and Lat - Discharge and re-enlistment

The SF 519-A is attached to this envelope with a paper clip until the films are processed. When the films are ready they are matched to the proper request and preserver and sent to the radiologist to be read. If the patient has been previously X-rayed in the clinic his old film file and preserver are taken from the files and the request is attached to it. When the films of the new examinations are processed, all are sent to the radiologist. The old films are needed in some instances to show progress of a disease or healing process.

After the films are read by the radiologist the report is typed on the SF 519-A. The radiologist either signs or initials the report and it comes back to you at the reception desk. The films are placed in the preservers and set aside for the files. The report is then separated. The original or top copy is sent to the ward or doctor who requested the examination. This copy is placed on the patient's SF 519, Clinical Record, Radiographic Reports, or, in the case of a flight surgeon's office, it may be attached to their worksheets. You will keep the duplicate or carbon copy for your files.

## INDEX CARD FILES

Some departments will make an index card from the request form. This index card file will be used to obtain old numbers in cases where more than one examination is made in the year. The index file is kept alphabetically. It may be divided into any number of separate files such as officers, airmen, dependents, civilian workers, etc. It could include, on the card, the reason for the examination such as application for OCS, annual physicals, discharge and re-enlistment films or food handlers. This will help in disposing of films which will be explained later on.

## FILING RADIOGRAPHIC FILMS AND REPORTS

Radiographic reports are filed in a number of different ways. The duplicate is placed in a prepared manila folder and fastened with a standard metal holder. This holder is then inserted in the film preserver so film and reports are together. This method, however, is time-consuming. It also can be expensive when thousands of patients are taken each year.

Many clinics combine the task of filing reports and making index card files by using the small photofluorographic film preservers. Information used for the card index is typed on the outside of the preserver and the reports for that patient are inserted in the preserver. When the old patient comes to the clinic for re-examination the entire record is pulled from the files and is attached to the request. When the films are matched the doctor will have the complete record.

Other clinics maintain just a plain alphabetical file of report forms. It is not a good practice to place your reports in the film preservers loosely. They can be torn or lost if they are handled often.

Film files are kept numerically. These files should be kept as neatly as possible. They should not be packed so tightly together that you have difficulty in removing film preservers when you need them. You should also watch the condition of the film preservers for wear and tear. Some patients may have a great many films filed in one preserver. These films may be used a great deal. When the preserver becomes worn it should be replaced to insure that no films are lost.

Films are filed in metal drawer cabinets and in exposed metal bins. You will see many improvised film containers. The best type of file is the open bin type. You can easily see the films you are trying to locate; the films do not bend out of shape or crack; and there is little danger of pulling a drawer out and injuring yourself.

## FILM LOCATOR LOG

Every clinic should use a film locator log. In some instances someone will ask to borrow the film and report file of a patient. Unless this is controlled you will have many difficulties.

Before you lend or give films to any person, you should make sure that these people have the proper permission to obtain the films. Generally, your clinic will have a policy regarding patient files.

The film locator log is a book kept by the clinic to show where films have gone that are missing from the files. It is kept to locate responsibility for missing films. This log will show the identification number of the film and report file, who checked out the file, who is to be responsible for the file, estimated date of return and number of films and reports checked out. It will also include date films and reports were returned.

### EXAMPLE OF FILM LOCATOR LOG

| Date | ID No. | Name of Patient | Out By | Responsible To | ETR | Qty | RTD |
|---|---|---|---|---|---|---|---|
| 5 Jan 57 | 1 | John Doe | A/1C Jones | Dr. Dee- Ortho | 7 Jan 57 | 3F/1R | 8 Jan 57 |
| 1 Mar 57 | 325 | Bob Lewis | Bob Lewis | "Permanently to civilian physician" | | | |
| 2 Sep 57 | 326 | Ernie Pyle | M/Sgt Pyle | Requested for files of new station on permanent retainment basis. | | | |

You will know exactly where every film is when people call for it. If one doctor has a set of films that another doctor needs, you can easily refer him to the right person. Your film locator log can save you a great deal of embarrassment, but you have to keep it accurate.

Each set of films and reports should be checked when they are returned to you to make sure there are no missing films and reports. The person responsible should not be relieved of his responsibility until missing films and reports have been returned.

## BEHIND AND AHEAD

You should now see how important it is that the examinations you perform should be scheduled so that the maximum use is made of the rooms, time and personnel. By scheduling properly, your patient will benefit by having his examinations done promptly and pleasantly.

You know that the request form SF 519-A, is used both for requesting and reporting the examination. You can check the form for accuracy and make any correction necessary. You know how to assign identification numbers from the daily log and where to locate old numbers from your card indexes. You know how the request is used for writing the number and sizes of films used, preparing negative preservers, report envelopes and card indexes, matching films, etc. You know that the original copy of the SF 519-A is sent to the requesting doctor and that the carbon copy is filed in your files.

You know how to file the SF 519-A and your films. You have seen some of the types of file containers you might encounter. You know how to keep track of your films by using the Film Locator Log when checking them out to various people.

The section ahead will tell you about disposing of the film that is taken in your clinic. You will find out what types of films have to be shipped to records centers, how to prepare them for shipment and where to send them. Film disposition is a big part of the administration of films and reports made in your clinic.

## DISPOSITION AND MAINTENANCE OF X-RAY FILM

X-ray films are part of a patient's medical record. Air Force Manual 181-5, dated 1 July 1956, Chapter 8, Section F is the authority for disposition of various categories of film and reports. Films on various types of personnel are sent to records centers for permanent retention. Other films are kept for a certain period of time and then salvaged or destroyed.

It is important that films be disposed of as prescribed in this manual. You can look at your own files and see if these were allowed to accumulate for years you would eventually occupy the entire hospital area. The time, money and space necessary to maintain expansive files would be prohibitive. Of course, some films are kept as a permanent record because they may be used in the future. Films of this type may provide the proof for claims against the government for injuries or disease occurring while the patient was on active duty. Certain categories of films are sent to other interested agencies throughout the country.

Proper disposition of these films is a big job in the X-ray clinic. Because of

the number of films that can be taken in one clinic, exact schedules should be maintained to see that films do not accumulate beyond workable proportions. A few films handled promptly will avoid a great deal of work later on.

## FINAL TYPE MEDICAL X-RAY FILMS

Final type X-ray films of personnel consist of enlistment and reenlistment, discharge and physical disability films. These films are to be maintained and retired as described in the following paragraphs.

AIRMAN FILMS. There are three categories of final type films for airmen.

- Chest X-ray films made as a part of the physical examination of all persons accepted for enlistment or reenlistment in the Air Force. Also included are those made as a part of the physical examinations of applicants for officer candidate schools, and the aviation cadet program, and for flying type duty in an enlisted status.

- Chest X-ray films made just prior to discharge of persons in an enlisted status.

- X-ray films made in the case of a person who is separated by reason of physical disability but does not need or accept transfer to a Veterans Administration facility at time of discharge.

OFFICER FILMS. There are five categories of final type films for officers.

- All X-rays of applicants for appointment as officers, warrant officers, and flight officers made as a part of the physical examination for appointment.

- All X-rays of officers, warrant officers, and flight officers made as a part of the physical examination for active duty.

- All X-rays of students or graduates of officer candidate schools (including flying and technical training schools) who are applicants for appointment, made as part of the physical examination for appointment.

- All X-rays of cadets at the Air Force and United States Military Academies and candidates thereto, made as part of the entrance physical examination.

- All X-rays of individuals in the above categories made at time of relief from active duty or separation.

RETIREMENT PROCEDURE. The airman and officer categories mentioned will be forwarded in service number sequence on a current basis (weekly or monthly depending upon the rate of accumulation) to the Federal Records Center, GSA, Kansas City, Missouri. The complete return address will be indicated on all packages of X-ray film.

PACKING AND IDENTIFICATION INSTRUCTIONS. Film will not be bent, rolled or folded. The individual's service number and name, in that order, will be typed, printed or stamped on the front of each container used for inclosing film. (In case of reenlistment of an OSI agent, disclosure of the individual's rank and service number will be protected as provided in AFR 160-74). Negative preservers will be requisitioned through medical supply channels under FSN 7530-612-3950 and 7530-612-4000.

Negative preservers measuring 4-3/8 by 10-3/8 inches will be used for all 4 by 10 inch and smaller film. Larger preservers will not be used for these sizes of film. Individual identifying data will be placed parallel with and no lower than 1-1/4 inches below the front open end of these preservers instead of in the space provided. After existing stocks of these preservers have been exhausted, they will be modified accordingly.

All film larger than 4 x 10 inches will be inclosed in negative preservers of the 14-1/2 by 17-1/2 inch size; however, if they are not available, envelopes of the same size will be used. Place the individual's service number parallel with the closed end and name in the space provided on the 14-1/2 by 17-1/2 inch preserver. If envelopes are used, flaps will be folded so that the glued surface does not come in contact with the film. Individual identifying data will be placed parallel with the front top edge of envelopes.

## VETERANS ADMINISTRATION BENEFICIARIES

X-ray film will be included in the clinical records of beneficiaries of the Veterans Administration and will be retained in the accumulating activity one year after annual cut-off and sent direct to the Federal Records Center at Kansas City, EXCEPT as indicated below:

- Air Force medical treatment facilities located in the Philippine Islands will send such clinical records and X-rays to the Veterans Administration Regional Office, Veterans Administration Building, David and Escolta, Manila, Philippine Islands.

- Air Force treatment facilities located in the Territory of Puerto Rico will send clinical records and X-ray film to the Manager, Veterans Administration Center, Post Office Box 4424, San Juan, Puerto Rico.

- Treatment facilities in the Territory of Hawaii will send such clinical records and X-rays to the Veterans Administration Regional Office, Post Office Box 3198, Honolulu 1, Hawaii.

- Treatment facilities in the Territory of Alaska will send clinical records and X-ray film to the Veterans Administration Regional Office, Goldstein Building, Juneau, Alaska.

## TRANSFERS TO OTHER MILITARY MEDICAL TREATMENT FACILITIES

When a patient is transferred to another medical treatment facility, all his X-ray film will be sent with him as part of his clinical records.

## CHEST X-RAYS OF REJECTED APPLICANTS AND REGISTRANTS

REJECTION FOR PULMONARY TUBERCULOSIS. Chest X-rays of applicants for enlistment or unacceptable registrants who are rejected by reason of pulmonary tuberculosis will be made available to the official state public health agencies of the rejected person's home state by local arrangement. Active tuberculosis is a reportable disease in all states. When the state health officer considers the report indicating the existence of the disease sufficient and does not desire the film, it will be salvaged or destroyed.

REJECTION FOR OTHER THAN PHYSICAL DISEASE. Chest X-rays of applicants for enlistment who are rejected for physical reasons other than disease of the chest will be destroyed or salvaged after findings have been entered on the physcial examination form.

## DISPOSITION OF UNACCEPTABLE REGISTRANT FILMS

Chest X-rays of unacceptable registrants for induction will be packaged and returned to the registrant's local board. Packages will be labeled "Exposed X-ray Films" and will indicate the name of the induction station making the shipment.

## UNIDENTIFIABLE EXPOSED X-RAY FILM

Exposed X-ray films of military and non-military personnel which cannot be identified will be salvaged or destroyed WHEN ENCOUNTERED.

## MOBILE X-RAY UNIT CHEST FILM

Negatives indicating pathology are made a part of the patient's clinical records. Negatives indicating a normal chest will be destroyed after 30 days.

## X-RAY FILM MAINTAINED IN ACTIVE MEDICAL FACILITIES

All medical X-rays, except those described in paragraph 333, AFM 181-5 and AFR 160-74 required to be transferred with the clinical records, will be maintained and disposed of as follows:

MAINTENANCE OF X-RAYS. X-rays will be maintained in numerical order by assigned X-ray number or by other positive means of identifying each patient's X-rays. X-ray files will BE CUT OFF AT THE END OF EACH CALENDAR YEAR and new files established on 1 January of each year. When an X-ray is made of a patient who has been previously X-rayed, the previous film will be brought forward and filed with the most recent film under the identification symbol assigned to the latter.

DISPOSITION OF X-RAYS MAINTAINED IN FACILITY. All X-ray indexes will be retired or disposed of concurrently with the X-rays to which they relate. X-rays will be cut off at the end of the calendar year, HELD 5 ADDITIONAL YEARS in the record staging areas or in any other manner consistent with prescribed procedures for adequate storage and servicing, and then be salvaged or destroyed.

Hospitals required by Headquarters, USAF to maintain clinical record libraries may file separately and retain indefinitely films adjudged to be of unusual interest or selected for teaching purposes. The related indexes and interpretations should also be retained.

## OTHER DISPOSITION OF FILMS

Paragraph 333, AFM 181-5 shows a few other conditions under which X-ray films are disposed.

TRANSFER TO A VETERANS ADMINISTRATION HOSPITAL. When a man is separated or retired for disability and is directed to be moved to a Veterans Administration Hospital, all of his X-rays will accompany his clinical record. The registrar will ask you to send films of these people to him so he can prepare the clinical record and send it with the patient.

AMERICAN RED CROSS PERSONNEL. X-ray films will be included in the clinical record of American Red Cross Personnel. Again, these films will be requested by the registrar's office.

ALLIED AND NEUTRAL ARMED FORCES PERSONNEL. All X-rays will be given to these personnel with their clinical records when they are transferred.

NAVY AND MARINE CORPS PERSONNEL. X-rays will accompany the clinical records of these personnel when they are transferred to a new treatment facility or transferred to a Navy administrative or liaison unit.

## WHEN ARE FILMS SENT OUT?

Final type airmen films can be sent to the Records Center whenever you have accumulated a sufficient number of them to make a package. The number of these films you take will determine how often you should send them. However, it is a good idea to check every thirty days. A few sent at frequent intervals will make it easier to keep track of your files. In this way you will not have a great number to prepare at once. There have been a number of clinics which have accumulated large amounts of these films and have had a great deal of trouble when it came time to dispose of them. The main principle is to keep your files clean and orderly.

The film that is maintained in your facility and held for 5 additional years should be arranged so that it can be disposed of readily. Let's say that you have a file of film for the years '52, '53, '54, '55, '56. You are now filing films of the current year 1957. On the first day of January 1958 you will start a new file of film. The film that you have for 1952 will be destroyed or salvaged. You see that you have five dead files of films and one current file.

## BEHIND AND AHEAD

You are now acquainted with the various types of film categories that you must

dispose to various agencies. You know when to send them and how to pack and identify them. You also know where they are sent. You realize now that you must keep up with your files so that they won't swamp you. You should follow the exact instructions given to you in AFM 181-5, Chapter 8, Section F to prepare your films for disposition.

The next section will deal with other departmental administration procedures, such as correspondence and reports.

## DEPARTMENT ADMINISTRATION

You have now completed the study of administration of the radiographic reports and film files. This part of your administration is only some of your paper work. The other administration with which you have to deal will relate to a number of different activities. Of course, most of the reports or correspondence you receive will pertain to the work of your clinic.

You will be required to know how to find answers to problems in Air Force, base and hospital publications. These will tell you the when, where, why, what and how to do things. You will answer and prepare correspondence of various kinds and learn how to file them. Reports will be submitted about your various activities. You will keep your records on your personnel, prepare duty rosters and provide men for details. Work orders will be made for installations and repairs in your clinic. Administration is a day-to-day problem.

### PUBLICATIONS

You have a series of publications in which you can find many answers to your problems. They will usually be located in your hospital sergeant major's office. This office will procure all of the necessary publications used in the medical facility. These publications are Air Force Regulations, Air Force Letters, Air Force Pamphlets and Air Force Manuals. There will also be base regulations and hospital policies. Go to the sergeant major's office and look through the publications that are there.

You will be interested mainly in the publications under the 160 series. These pertain to the medical services. Some X-ray information is found here. AFR 5-2 is an index to all of the various types of Air Force publications. It is a good idea to periodically check through the index for new information or directives. Usually the sergeant major will send these publications, which are of interest to your clinic, to you so you are aware of their provisions.

Air Force Regulation 9-2 is an index to all of the various forms you will use in your work. It shows those forms which are approved by the Air Force for use. You will also have some local type forms that your particular clinic or hospital uses.

### CORRESPONDENCE

You should know what a military letter looks like and something of how it is prepared. Most of your business will be transacted over the telephone, but there will

be times when you will need to answer inquiries made to your clinic with a military letter. Air Force Manual 10-1, dated 1 March 1956, is the manual used in preparing correspondence. It will show you how to space and arrange a military letter. In some clinics these letters are prepared by the sergeant major's office and you will simply supply the information.

You will need to file some of the correspondence you receive. Air Force Manual 181-4 provides you with a guide for setting up your filing system. You must remember that ANYONE should be able to find a letter in your files. If you go on leave and are the only one who knows where things are located, the fellow who takes over will have trouble until you return. Your whole department should never have to depend upon one man.

You will do a great deal of corresponding with sections in your own hospital. In the hospital you will have a section, usually the sergeant major's office, which distributes correspondence to the various departments and clinics in the hospital. Instead of running to each individual department or clinic you will send all of your correspondence to this distributing center.

Most of this intra-hospital communication is done with DD Form 96, Disposition Form and DD Form 95, Memo Routing Slip. The disposition form is usually filed because it will relate to certain operations that should be recorded. The Memo Routing Slip, however, is never filed because it is generally used just to route material through interested departments. Air Force Manual 10-1 is also the guide to using these two forms.

## REPORTS

You will be required to submit various reports on activities in your clinic. Some of these are a part of medical reports required of all hospitals, and others are for use by base or Air Force agencies.

PROFESSIONAL ACTIVITIES REPORT (AFR 160-63). This is a report on the amount of work of various types that your clinic does, problems in your clinic or any other remarks that are considered important. The X-ray clinic will be responsible for Part IV, Report of Radiology Services (Figure 13-1).

The Professional Activities Report is the ultimate end for other types of reports. These reports are known as monthly reports, bi-monthly reports, Report of Radiology Services, etc. All of them require you to present the number of various examinations your clinic has performed, number of films used of various sizes, number of military, civilian and dependents, etc. Usually these are nothing more than worksheets for the report proper. This report is sent on DD Form 96 to the Chief of Professional Services. All of the various department reports are consolidated and sent forward as the Professional Activities Report.

OUTPATIENT REPORT (AFR 160-80). The outpatient report is used to record the number of visits that certain categories of patients make to your hospital. It is used to provide current data to the Surgeon General's office on specific conditions among outpatients and the extent of the medical workload on your hospital. This information is used in program planning, computing the number and type of personnel your hospital needs, and helps determine the kinds of illnesses being treated at spe-

cific bases and areas.

You will need to keep a record of the number of visits made by the following categories of personnel.

- Active duty military - These are officers and enlisted persons in the Army, Navy, Marine Corps and Air Force on extended active duty.
- Short tour active duty - These are patients performing short tours of active duty of less than 91 days with the Armed Forces of the United States. (Reservists, National Guard, ROTC, etc.)
- All military dependents - These are dependents of active duty, retired and deceased military personnel.
- United States civilian employees - These are civilian employees and their dependents who receive treatment or examinations in your clinic.
- Others - This will be the catch-all for other categories who are not included above. This may be used mostly overseas.

PART IV

PROFESSIONAL SERVICES REPORT

1. Number of examinations 3,623
   a. Fluoroscopic 123
   b. Radiographic 3,500
2. Total number of X-ray plates exposed 6,324
3. Number of treatments, if any 53
   a. X-ray 48
      (1) Deep 18
      (2) Superficial 30
   b. Radium 3
   c. Other 2 (Radioactive isotopes, etc.)
4. Remarks, unusual problems, etc.
5. Officers assigned:

| NAME | DOS | GRADE | AFSC'S | Proportional of total time assigned this service |
|---|---|---|---|---|
| Amos, D.R. | 12 Sep 58 | Major | 9636 | |
| | (Date of separation: Day, month, year) | | (With suffix) | 100% |

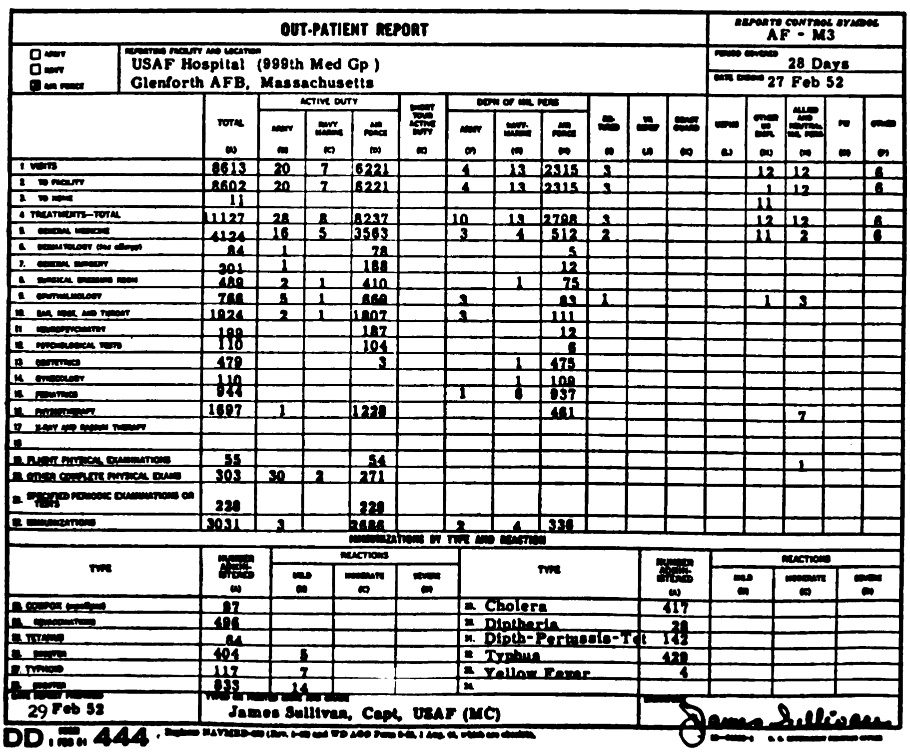
CHIEF OF RADIOLOGY Amos, D.R., Major USAF (MC)

| DATE | TYPED OR PRINTED NAME AND GRADE | SIGNATURE |
|---|---|---|
| 13 Oct 57 | D.R. Amos, Major, USAF, (MC) | |

Figure 13-1 Professional Activities Report

A visit is made when a patient reports for any medical advice or treatment. You can only record one visit for one patient per day. Even if you X-ray him three times in the day he has only made one visit. Also he must come directly to the clinic for an examination to be counted as a visit. You cannot count his visit if he is coming to X-ray as a part of a course of observation or treatment. He will be counted by the department he first visited. This will be confusing until you have worked with this particular system for a time. You may never list a patient as a visit for regular routine radiographic work because each request is signed by a physician or another section. This means that the patient visited the referring section first and has already been listed on that section's record as an outpatient visitor.

DD Form 444, Outpatient Report, is made out by the front office, but information for lines 17, 18 and 20 will be furnished by you to them on a DD Form 96. Line 20 may reflect any mass screening or test examinations such as you might perform for chest surveys, food handlers, etc. Line 17 will show the total number of X-ray and radium therapy treatments of any type, whether or not the examination was incidental to a "visit" or "examination" reported somewhere else on the form. This figure will probably be taken from your Professional Activities Report. Line 18 will show the number of fluoroscopic examinations made, whether or not they were incidental to a "visit" or "examination" reported somewhere else on the form. You can only report one fluoroscopic examination for one individual on any given day, however, Generally, what this report will boil down to is a record of the number of fluoroscopic examinations you have performed (Figure 13-2).



OUT-PATIENT REPORT

Reports Control Symbol AF - M3

Air Force

USAF Hospital (999th Med Gp)
Glenforth AFB, Massachusetts

Period covered: 28 Days

Date ending: 27 Feb 52

| | (A) | (B) | (C) | (D) | (E) | (F) | (G) | (H) | (I) | (J) | (K) | (L) | (M) | (N) | (O) | (P) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Visits | 8613 | 20 | 7 | 6221 | | 4 | 13 | 2315 | 3 | | | | 12 | 12 | | 6 |
| 2 To facility | 8602 | 20 | 7 | 6221 | | 4 | 13 | 2315 | 3 | | | | 1 | 12 | | 6 |
| 3 To home | 11 | | | | | | | | | | | | 11 | | | |
| 4 Treatments—Total | 11127 | 28 | 8 | 8237 | | 10 | 13 | 2798 | 3 | | | | 12 | 12 | | 6 |
| 5 | 4124 | 16 | 5 | 3563 | | 3 | 4 | 512 | 2 | | | | 11 | 2 | | 6 |
| 6 | 84 | 1 | | 78 | | | | 5 | | | | | | | | |
| 7 | 301 | 1 | | 188 | | | | 12 | | | | | | | | |
| 8 | 489 | 2 | 1 | 410 | | | 1 | 75 | | | | | | | | |
| 9 | 768 | 5 | 1 | 669 | | 3 | | 83 | 1 | | | | 1 | 3 | | |
| 10 | 1924 | 2 | 1 | 1807 | | 3 | | 111 | | | | | | | | |
| 11 | 199 | | | 187 | | | | 12 | | | | | | | | |
| 12 | 110 | | | 104 | | | | 6 | | | | | | | | |
| 13 | 479 | | | 3 | | | 1 | 475 | | | | | | | | |
| 14 | 110 | | | | | | 1 | 109 | | | | | | | | |
| 15 | 944 | | | | | 1 | 6 | 937 | | | | | | | | |
| 16 | 1697 | 1 | | 1229 | | | | 461 | | | | | | 7 | | |
| 17 | | | | | | | | | | | | | | | | |
| 18 | | | | | | | | | | | | | | | | |
| 19 | 55 | | | 54 | | | | | | | | | | 1 | | |
| 20 | 303 | 30 | 2 | 271 | | | | | | | | | | | | |
| 21 | 228 | | | 228 | | | | | | | | | | | | |
| 22 | 3031 | 3 | | 2686 | | 2 | 4 | 336 | | | | | | | | |

| Type | (A) | (B) | (C) | (D) | Type | (A) | (B) | (C) | (D) |
|---|---|---|---|---|---|---|---|---|---|
| 23 | 87 | | | | 29 Cholera | 417 | | | |
| 24 | 496 | | | | 30 Diptheria | 28 | | | |
| 25 | 84 | | | | 31 Dipth-Pertussis-Tet | 142 | | | |
| 26 | 404 | 5 | | | 32 Typhus | 429 | | | |
| 27 | 117 | 7 | | | 33 Yellow Fever | 4 | | | |
| 28 | 833 | 14 | | | 34 | | | | |

29 Feb 52

James Sullivan, Capt, USAF (MC)

James Sullivan

DD Form 444

Figure 13-2 Outpatient Report

Air Force Form 566, Daily Record of Outpatient Treatment may be used to obtain your figures for the Outpatient Report. You can see how it is used from the illustration (Figure 13-3).

| DAILY RECORD OF OUT-PATIENT TREATMENT | | | | | | | | CLINIC: DERMATOLOGY | | | | | MONTH AND YEAR: FEBRUARY 52 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ACTIVE DUTY | | | | DEPENDENTS | | | | | | | | | | |
| DATE | ARMY | NAVY | AIR FORCE | SHORT TOUR ACTIVE DUTY | ARMY | NAVY | AIR FORCE | RETIRED MILITARY PERSONNEL | VA BENEFICIARY | COAST GUARD | U.S. PUBLIC HEALTH SERVICE | OTHER U.S. EMPLOYEES | ALLIED & NEUTRAL MILITARY PERSONNEL | PRISONER OF WAR | OTHER |
| JAN 31 | | | 4 | | | | | | | | | | | | |
| FEB 1 | | | 3 | | | | | | | | | | | | |
| 2 | | | | | | | | | | | | | | | |
| 3 | | | | | | | | | | | | | | | |
| 4 | | | 6 | | | | | | | | | | | | |
| 5 | | | 5 | | | | | | | | | | | | |
| 6 | | | 2 | | | | 1 | | | | | | | | |
| 7 | | | 7 | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | | |
| 11 | | | 3 | | | | | | | | | | | | |
| 12 | | 1 | 4 | | | | | | | | | | | | |
| 13 | | | 2 | | | | | | | | | | | | |
| 14 | | | 5 | | | | 1 | | | | | | | | |
| 15 | | | 1 | | | | | | | | | | | | |
| 16 | | | | | | | | | | | | | | | |
| 17 | | | | | | | | | | | | | | | |
| 18 | | | 7 | | | | | | | | | | | | |
| 19 | | | 3 | | | | | | | | | | | | |
| 20 | | | 2 | | | | 2 | | | | | | | | |
| 21 | | | 4 | | | | | | | | | | | | |
| 22 | | | 5 | | | | | | | | | | | | |
| 23 | | | | | | | | | | | | | | | |
| 24 | | | | | | | | | | | | | | | |
| 25 | | | 3 | | | | | | | | | | | | |
| 26 | | | 6 | | | | 1 | | | | | | | | |
| 27 | | | 3 | | | | | | | | | | | | |
| TOTAL | | 1 | 78 | | | | 5 | | | | | | | | |

AF FORM 1 FEB 50 566

Figure 13-3 Daily Record of Outpatient Treatment

THE MONTHLY REPORT OF SALARY DISTRIBUTION (AF Form 675-AFR 160-66). This is a report that is made once a month. It is used to show the utilization of personnel and cost of these personnel. It is necessary to prepare it as accurately as possible. An error could probably bring about a change in your personnel eventually. This report is used in the preparation of the Medical Services Staffing Report, AF Form 201.

The AF Form 675 is made up in three copies. Two of these copies are sent to the sergeant major's office. You will keep the last copy for your files. Instructions for preparing the report will be found in AFR 160-66 and its changes. Some hospitals have developed a worksheet which is used to perform the preliminary figures. The worksheet helps to avoid making changes on your printed form and will allow you to catch any errors before you use your form. You are only issued three forms a month on which to make the report so you can see that a worksheet is a good thing to use.

HISTORICAL REPORTS. These reports are required of every activity in the Air Force. Your clinic will also submit a historical report. These are reports of the various activities that have taken place in your clinic for a specified period.

FIRE REPORTS. These are required of every section on the base. These reports will indicate any fire hazards that may exist in your clinic so that appropriate action can be taken to eliminate them. At least once a month you will check your sec-

tion for various hazards and see that your fire extinguishers are in proper condition. You will either fill out a prepared fire report form or indicate on a DD Form 96 the condition of your section. These reports are sent to the sergeant major's office.

CONSULTANT REPORTS. These are prepared in some clinics that have no assigned radiologists. Civilian doctors are paid as consultants to come to the clinic and read the films that are taken. The report will indicate the fact that a consultant was used, and other particulars required by your hospital administrative section.

RECORDS MANAGEMENT REPORT. This is one of the reports required by AFM 181-5 on the disposition and control of all correspondence files and other records that you have accumulated in your clinic. As with the film and radiographic reports files, you will have to keep track of other paperwork you have in the clinic. Your hospital is required to report, periodically, the amount of these files to the records control officer. Information on this report is found in Chapter 4, AFM 181-5.

A Monthly Linear Control Inventory is required in all sections too. This is the measurement of all records you have stored in your clinic. The "linear" measurement will be in feet. If you have a file drawer that has two feet and eight inches of records stored in it, you will report the inches in twelfths. For example: 2-8/12 feet of records. Each section will have a Records Control Schedule sent to it from the hospital records officer. This will show the amount of records stored in your section and will give directions for disposing of the various categories of these records. Each year you will submit an Annual Records Disposition Schedule Report to show the amount of records and the categories that you have disposed of or sent to records centers. You will find complete explanations for disposition of all your records in AFR 181-5.

Other reports, that are peculiar to each installation, may be required. The number and purpose of these are not important to you here and you will have to learn about them in your own particular clinic. Usually they are not difficult or detailed and can be prepared from your current logs or files.

There are more administrative tasks that you must perform but these will be seen in later chapters. The important thing about administration is to accomplish each day all that is necessary. Pieces of paper can pile up very rapidly. As an administrator you have to keep up with it. You must keep up with suspense dates on all reports or your commander may find that you are not cut out for your job. Don't ever feel that administration in your department is a secondary job.

## BEHIND AND AHEAD

You are now familiar with some of the various types of reports that you will be expected to prepare. You know something about a military letter, disposition forms and memo routing slips. You should know where to look for information in Air Force base and hospital regulations, letters, manuals and pamphlets. To become familiar with these things you should make periodic checks with the publications files in the sergeant major's office and learn the details of using these files.

Ahead of you, in the next section, is information on your supply problems. You

will learn how to order supplies, how to control them, account for them and how to turn in worn property. Supply administration is also a big job in your clinic. Although many people do not realize it, they are spending their own money when supplies are used improperly or wastefully.

## SUPPLY ADMINISTRATION

Where do you get things to work with? How do you get rid of old and worn out equipment? What do you have to do if you want something that is not a standard stock item? Who is responsible for all of the materials and equipment you will be using? All of these questions will be answered in this section on supply administration.

To do your job and do it well requires many different articles of supply. You will get everything you need from medical supply. You will have to be careful, however, because you don't have as much credit there as you might in town. This doesn't mean that you can't get everything you need, but they will see that you don't get so much that you waste it. Medical Supply is the department store for the medical group. It will supply you with X-ray film or high KV therapy machines. But there has to be a system so that you can get supplies when you need them - in the quantities you need. You will notice that NEED is the key word. Supply is a big job and one that has to be minutely controlled to function properly.

### BUDGETING

How do you determine how much of each item you will need? One of the big factors in the supply procedures is PLANNING. You will have to learn how to budget your department. When you receive your pay every month you have to determine what to buy and what bills to pay. The same thing is true for your hospital. Each year your hospital is given just so much money to run on for the period. This money is determined by YOU and all the other sections in the hospital.

You will make an estimate of the amount of supplies that your clinic will consume throughout the year. You will also estimate the cost of certain repairs, installations and additional new equipment you might need in your clinic. These estimates are then sent to the front office and compiled with all the other department estimates into one figure. The total amount that it will take to run your hospital will be sent to Washington and studied. After each detail is discussed, as to the absolute necessity of the items to your mission, an appropriation will be made to your hospital. The amount of money may be what you asked for and it may not. There are many factors which will influence the amount any particular area will receive, as you well know.

The money that is made available to your hospital is then divided among the various sections based on the estimates they made. However, you do not see the money. It is part of the supply system. You may use every cent you estimated and you may not. If you don't use all your money it can be used by another section for additional equipment, etc.

You still must know how to go about this budget business. What things do you

have to figure in your estimate? To find this out you should know about expendable and non-expendable supplies and whether they are medical or Air Force supply items.

Expendable supplies are those articles that are used up like films, developer, lead numerals, paper, pencils, paper clips, etc. To keeptrack of items of this type the supply system puts them into classifications. Items that are of a particular part of the medical service operation are classified as "Medical". Things which are not used in particular departments for specific medical purposes are "Air Force". The X-ray films, developer and lead numerals are medical items used specifically in the X-ray clinic. The paper, pencils and paper clips are used in every activity and are general Air Force items.

Non-expendable equipment is that equipment which lasts for an extended period of time. Examples of medical non-expendable equipment are X-ray machines, cassette changers and cassettes themselves. Examples of non-expendable Air Force equipment are metal chairs and desks.

In budgeting you have to consider how many films you will use, how much developer you will need, etc. Your expendables are a major part of your budget because you must have enough to last you. In determining how much you will need you should take into consideration the effect a new organization might have on your consumption of film. Loss of a base unit would lessen needs. You can think of methods of saving films like accurate training and using more views on one film, etc. Budgeting is thinking ahead and planning for all possible changes that may create a shortage or an overage of supplies.

Budgeting for non-expendables will require an absolute justification as to why these items are required in your work. You will have to assure your supply officer that your efficiency will be increased. You cannot say that you would just like to have something - you must sell your supply officer on its value to your clinic. Supply is there to help you get what you NEED.

Other things are necessary in estimating a budget. You will have to think of the possible spare parts for your machines such as electron tubes, cables, X-ray tubes, etc. You will need to estimate any repair that may be needed in the clinic such as remodeling, painting and the like. You will need to think of the cost of maintenance checks on your equipment if you have no military medical maintenance personnel available. You will find that budgeting is a thinking job and that when time arrives to estimate your costs, the amount of thinking you do will be reflected in the operation of your clinic.

HOW TO FIND BUDGET ESTIMATES. You are aware now of the importance of budgeting, but how do you arrive at the necessary figures you need for the estimate? You will need to know what you used in the past. From past figures you can project into the future. You must make a list of all items that you use in your clinic. This list should include everything from paper clips to X-ray tubes. You must look ahead for any possible increase in your clinical operations such as approved additions to your clinic, new examinations and procedures.

From your previous supply records you can obtain the amount of supplies you used. You will list these with any decrease or increase that you think necessary. The items should be kept separated into Medical and Air Force expendable and non-expendable.

Let's take a few items and see just what they would cost you in a year's time if you had to buy them. Usually you will have a stock level which will be more fully explained later on. However, to illustrate, let's say you get so many items every two weeks throughout the year. The list below could be used as a starting point.

| ITEM | USED PER MONTH | UNIT PRICE | TOTAL PRICE |
|---|---|---|---|
| Paper clips | 12 boxes | $.04 | $.48 |
| Bond typing paper | 1 ream | 2.55 | 2.55 |
| Developer, 5 gal. | 8 bottles | 2.46 | 19.68 |
| Film, photofluorographic | 4 rolls | 7.88 | 31.52 |
| Film, 8 x 10 | 15 boxes | 10.26 | 153.90 |
| Film, 10 x 12 | 40 boxes | 15.10 | 604.00 |
| Film, 14 x 17 | 10 boxes | 28.94 | 289.40 |
| Fixer, 5 gal. | 8 bottles | 2.00 | 16.00 |

These figures add up to the total of $1,117.53 per month. Multiplying this by 12 equals $13,410.36. This figure is just for eight commonly used items in your clinic. There are over 150 hospital and dispensary radiology clinics in the Air Force. Using these figures as the average for 100 clinics, you would spend $1,341,036.00 in just one year on eight common items. You should see now that budgeting in the Air Force is important.

## STOCK LEVELS

Stock levels are the amount of supplies you will need for certain periods of time. Once your budgeting has been completed you will know what things you will need and generally what quantities will be required. This amount is then broken down into how much you will require to operate two weeks. You will not be given the whole year's supply because you won't have a place to store them, some materials must be fresh, etc.

You must determine how much film, developer, negative preservers, pencils and other items you will use during a two week period. The amount of each item will then be your stock level for that item. As an example, you may use twenty boxes of 10 x 12 film every two weeks. Your stock level would be 20 boxes.

If you find that you do not use that much or that you do not have enough of various items, you will send a disposition form DD 96 to your supply officer requesting that your stock level be increased or reduced. You should only order what you ACTUALLY need and use.

CONTROL NUMBERS FOR ISSUE SLIPS. Before you go into how to prepare an issue slip you should know about the "Registei of Control Numbers". AF Form 115a. (Figure 13-4). This register will help you in keeping track of all your accounts and also allow you to keep a check on your issue slips.

The control number is used on your issue slips. It will consist of the day, month and number of the document. As an example: you make an issue slip on 15 January and it is the first one you have made. Your control number will be "1-15-1". From that date on you will use the next consecutive number for your third number. If you made another issue slip on 20 January that control number would be "1-20-2".

You will fill out the AF Form 115a with ink, typewriter or indelible pencil. If you have to correct any entry you will draw a line through the incorrect entry so it can still be read and place the correction above the line.

**REGISTER OF CONTROL NUMBERS**

ORGANIZATION OR UNIT: Department of Veterinary Services — DATE OR FISCAL YEAR: 1957

| CONTROL NUMBER | TYPE OF DOCUMENT | FROM OR TO | PROPERTY CLASS. WORK ORDER. UN ACCOUNT. OR AF COST CODE | DATE FILED | ITEM IDENTITY OR OTHER INFORMATION |
|---|---|---|---|---|---|
| 8-6-1 | 1/S | AFM 9999 | 6810 | 8/8 | 57-9000 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

AF FORM 115a 1 AUG 52 PREVIOUS EDITIONS OF THIS FORM MAY BE USED. REPLACES AF FORM 237, 1 MAR 51, WHICH MAY BE USED.

U. S. GOVERNMENT PRINTING OFFICE : 1955 O - 317183

Figure 13-4 AF Form 115a

## ISSUE AND TURN-IN PROCEDURES

Now that you know about the control numbers that must be used you will learn about how supplies are issued to you and how you turn-in old or broken equipment. A recent revision of supply procedures has consolidated the two former issue and turn-in slips into one form. This form is the DD Form 1150.

ISSUING. You will request issue for supplies according to various types of "schedules". These are set up by your medical supply. You will make a separate DD Form 1150 for all items listed in the categories below.

1. Expendable and non-expendable
2. Stock Fund and Nonstock Fund Items
3. Initial and replacement
4. Security and non-security
5. Diagnostic radioactive isotopes

Non-medical items will be requested on separate issue slips for each class and sub-class of Air Force property. The number of copies and schedule of submission of these slips will be determined by your supply officer.

**TURN-IN PROCEDURE.** You will find that you will be required to turn-in equipment or items for a number of reasons. Some of these reasons may be: items on hand exceed authorization, equipment worn out through proper use or broken through carelessness or neglect, turn in ordered by higher authority, or need for some items may no longer exist.

You will make separate DD Form 1150's for expendable, non-expendable, serviceable, unserviceable, standard, non-standard items, security and non-security items.

**PREPARATION OF TURN-IN SLIPS.** The same DD Form 1150 is used as a turn-in slip. It differs only in the preparation when used as a turn-in slip. You will not place serviceable turn-ins and non-serviceable turn-ins on the same slip.

**REQUEST FOR ISSUE OR TURN-IN** — X ISSUE / TURN-IN — SHEET NO. 1 — NO. OF SHEETS 1 — 5. REQUEST NUMBER 4-1-214

1. FROM: Pharmacy, WPAFB, Building 830, ext 6-2332 — 6. DATE MATERIEL REQUIRED: — 8. VOUCHER NUMBER: 4001-57

2. TO: AFM 2300 — 7. PRIORITY: Expendable or X — 9a. POSTED (initials & date): rms 4/1/57 — b. POSTED (initials & date): hms 4/2/57

3. ACCOUNTING AND FUNDING DATA: Issue of material contained hereon from the Med. Dent. Division, AF Stock Fund is authorized and is properly chargeable to XXX XX XXX furnished under Obligation Authority No XX dated XX. Signed by MSO.

4. END ITEM IDENTIFICATION — a. NAME AND MANUFACTURER — b. MODEL — c. SERIAL NUMBER — d. PUBLICATION

| ITEM NO. a | STOCK NUMBER AND DESCRIPTION OF MATERIEL AND/OR SERVICES b | CODE* c | UNIT OF ISSUE d | QUANTITY e | SUPPLY ACTION f | UNIT PRICE g | TOTAL COST h |
|---|---|---|---|---|---|---|---|
| 1 | 6505-104-8000 Alcohol: | I | Can | 1 | 1 | .69 | .69 |
| 1 | 6505-107-3727 Whiskey: | I | Btle | 3 | 3 | .68 | 2.04 |

*ISSUE - I-Initial; R-Replacement    TURN-IN - U-Unserviceable; S-Serviceable    10. SHEET TOTAL 2.73

| 11. ISSUE OR TURN-IN OF QUANTITIES IN "QUANTITY" COLUMN IS REQUESTED | DATE | BY | 12. RECEIVED QUANTITIES IN "SUPPLY ACTION" COLUMN | DATE | BY |
|---|---|---|---|---|---|
| | 1 April 57 | John J. Jones 1/LT | | 3 April 57 | George G. Collins A/1C |

DD FORM 1 JUL 56 1150

Figure 13-5 Request for Issue or Turn-In

## SUPPLY REPRESENTATIVE AUTHORIZATION (AF Form 93)

Before you can draw any supplies you must be authorized by your department property officer. The responsible property officer can delegate to you the authority to sign for either non-expendable or expendable supplies or for both types. He is still responsible, however.

Specimen signatures will be submitted to the medical supply. These signatures are submitted on a DD Form 96.

Air Force Form 93 is a small card like your pass. This card will have your name, grade, serial number and signature on it. The card must be signed by your responsible property officer and countersigned by the base medical supply officer. The card will also state how much authority is delegated to you. Whenever you draw supplies you will have to present your authorization card. Your responsible property officer will collect and destroy all cards if he wishes to cancel your authority to draw supplies. He will notify the base medical supply officer in writing that he has cancelled your authority to draw department supplies.

You have been reading about non-expendable and expendable equipment, control register numbers and issue slips. Before you can go further you must learn about the Base Medical Plant Account.

## BASE MEDICAL PLANT ACCOUNT

All non-expendable medical equipment is "loaned" to your department by the base medical supply officer. The base medical plant account is a record of this loan. When the equipment is issued to your department you are in "custody" of the equipment and RESPONSIBLE for it.

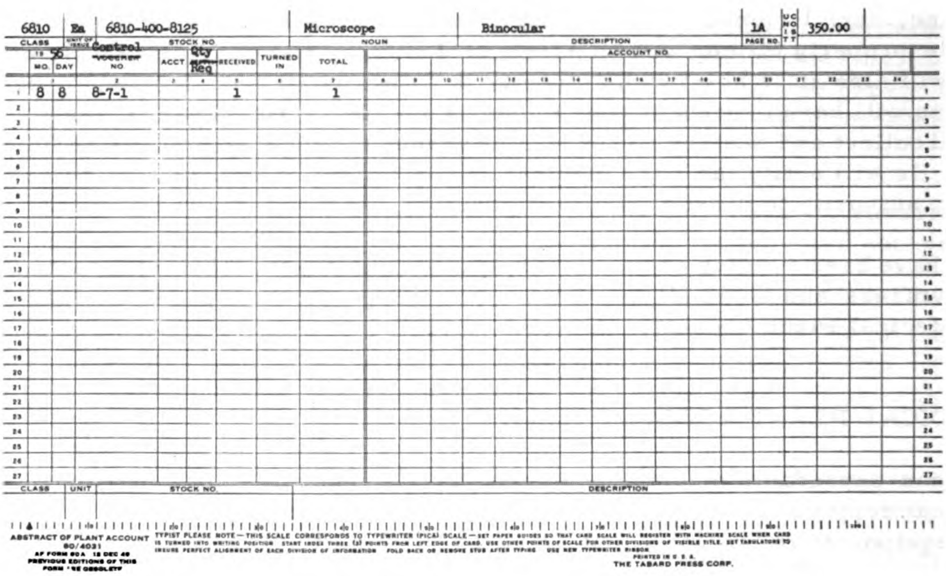
The commander of your hospital will assign responsible property officers in each section. These responsible property officers may be non-commissioned officers, civilians or officers. If you are a non-commissioned officer you will sign for all non-expendable property when assigned as responsible property officer. This equipment is your property. You will see that it is used properly and you will safeguard it to the best of your ability. It is important for you to remember that the property is YOURS and YOU will be responsible for any misuse, loss or negligent damage to any property in your custody.

Custody receipt account numbers are given to each responsible property officer by the medical plant account officer. This number will be YOUR account number and will be used on all issue and turn-in slips. An example of how your number may appear is "S-32", "M-1004". This number will have the same significance that an account number has on an installment book used to make payments on an automobile. Whenever any transactions are made that affect your account you will use your account number to identify yourself. In your situation you will be dealing with supplies and not with cash.

Inventories are made of all medical plant account property in your clinic. Some clinics have an inventory once each month, but all activities are required to have an annual inventory of all property on their medical plant account. Inventories are nothing more than counting the non-expendable items that you have signed for to see that they are where they are supposed to be, being used properly, and still in serviceable condition. If your department has two X-ray machines and twelve cassettes, you will have to find and account for this equipment.

Air Force Form 90A is maintained by every responsible property officer (Figure 13-6). This form is used to record the items of non-expendable property that you have been issued or have turned-in. You will keep a jacket file on all of the issues

**and turn-ins that affect your plant account. This form will allow you to see immediately the status of your medical plant account.**



| CLASS | UNIT OF ISSUE | STOCK NO | NOUN | DESCRIPTION | PAGE NO | UC NO IS TT | |
|---|---|---|---|---|---|---|---|
| 6810 | Ea | 6810-400-8125 | Microscope | Binocular | 1A | | 350.00 |

| | 19 56 MO. | DAY | Control ~~VOUCHER~~ NO | ACCT | Qty ~~…~~ Req | RECEIVED | TURNED IN | TOTAL |
|---|---|---|---|---|---|---|---|---|
| | 1 | | 2 | 3 | 4 | 5 | 6 | 7 |
| 1 | 8 | 8 | 8-7-1 | | | 1 | | 1 |

ACCOUNT NO

CLASS | UNIT | STOCK NO. | DESCRIPTION

ABSTRACT OF PLANT ACCOUNT
90/4031
AF FORM 90A 15 DEC 49
PREVIOUS EDITIONS OF THIS FORM '45 OBSOLETE

TYPIST PLEASE NOTE — THIS SCALE CORRESPONDS TO TYPEWRITER (PICA) SCALE — SET PAPER GUIDES SO THAT CARD SCALE WILL REGISTER WITH MACHINE SCALE WHEN CARD IS TURNED INTO WRITING POSITION. START INDEX THREE (3) POINTS FROM LEFT EDGE OF CARD. USE OTHER POINTS OF SCALE FOR OTHER DIVISIONS OF VISIBLE TITLE. SET TABULATORS TO INSURE PERFECT ALIGNMENT OF EACH DIVISION OF INFORMATION. FOLD BACK OR REMOVE STUB AFTER TYPING. USE NEW TYPEWRITER RIBBON.

PRINTED IN U. S. A.
THE TABARD PRESS CORP.

**Figure 13-6 AF Form 90A**

**Relief from property responsibility is an important step. If you should be transferred and are the responsible property officer for your department, you must be relieved of your supply responsibility. You do this by inventorying all your plant account property with the man who is going to assume your responsibility. When there are any shortages or missing equipment you must either find or account for it. The man who will assume your responsibility will be very conscientious about signing for only that property he has actually seen. If your account is correct you will be relieved by a Personnel Action Memorandum. Be sure to keep a copy of this memorandum in your personal file for future reference.**

**The plant account will be assumed by the new responsible property officer and all records will show his account number.**

## LOCAL PURCHASE

**There will be times when you will need an item which is not available through regular Air Force or medical supply channels. You get these supplies by purchasing the item from businesses or stores in the community next to your base. These purchases of supplies or equipment are known as local or special purchase items. Air Force Regulation 70-16 provides a list of the authorities to be used in purchasing items locally. Local purchase is authorized to obtain non-standard items as NEEDED, standard catalog items in EMERGENCY, and repair services and parts as NEEDED.**

**Local purchasing is rigidly controlled. When a subsitution cannot be used or when situations require immediate procural of an item in an emergency, you will use local purchase procedures. You must realize that you will need good justification**

(good reason) for wanting any particular item. Again, you must sell your supply officer on the necessity of any local purchasing you may want to do.

You will need to forward the information on the item or services you need to the medical supply officer. The medical supply section will see that you get the item or service if the request is approved. In sending your request to the medical supply officer you should include all the information that identifies the article or service you want, the estimated cost, and places you can obtain these articles or services. This is done with DD Form 1150.

## DEPARTMENT LINEN SUPPLY

Each department in the hospital will use some linen. This linen is rigidly controlled and care must be exercised in keeping track of it. You will be using sheets, towels, hand towels, pillowcases, etc.

Generally, the linen control officer will determine a stock level from figures submitted to him from the department. You will draw your linen according to this stock level. AF Form 581, Linen Supply Record may be used for establishing this stock level.

AF Form 581 is also used to exchange your linen. Usually this exchange will be performed in the mornings on a daily basis. At the top of the sheet you will see in the "This Record" space the department, such as "X-ray Department, Daily Issue" or "X-ray Department, Weekly Issue". The list of common linen items is filled in with those items you are going to exchange. The date is necessary at the top also. The signature at the bottom of the sheet is a receipt for the linen marked on the face of the form. See figure 13-7, next page.

## YOUR UNIT ALLOWANCE LIST (UAL)

You will be hearing and seeing the term "UAL". This is an abbreviation of Unit Allowance List. This list is a list of the specified equipment that you are authorized to have in your department. Any additional equipment you think you need will have to be approved as a part of your UAL before you can request it.

The major air command determines what items are needed by each of its organizations. At the major air command headquarters there is a board which reviews all requests for changes in an activity's UAL. Your UAL is your authorization to order new equipment. As an example, you are authorized two X-ray machines, but only have one. Because your UAL gives you two machines you can order the other machine. However, if you only have one machine authorized and really need another machine because of an increased workload, you will need to request an increase in your UAL.

Requests are made on a DD Form 96 and sent to supply. A complete description of the item that is required will be submitted and a studied justification must accompany the request. Medical supply sends the request on until it reaches the major air command UAL Board. Once it is approved, you are authorized the new item and can order it.

**LINEN SUPPLY RECORD**

| THIS RECORD | DATE |
|---|---|
| DAILY ISSUE WARD 2 | 4 Feb 52 |

| ITEM | QUANTITY |
|---|---|
| APRONS. COOK | |
| BAGS. CONVEYOR | |
| BAGS. LAUNDRY | 5 |
| BLANKETS. O.D. | |
| BLANKETS. WHITE | |
| CAPS. COOK | |
| COATS. CONVALESCENT | 4 |
| COATS. OPERATING | |
| COATS. PAJAMA | 32 |
| COUNTERPANES | |
| COVERS. ASSORTED | |
| COVERS. MATTRESS | |
| COVERS. SCREEN | |
| GOWNS., OPERATING | |
| MASKS. OPERATING | |
| MATS. BATH | 3 |
| PILLOW CASES | 40 |
| SHEETS | 50 |
| SLINGS | |
| ROBES. BATH | 32 |
| TABLE CLOTHS | |
| TOWELS. BATH | 32 |
| TOWELS. DISH | 4 |
| TOWELS. HAND | 36 |
| TROUSERS. CONVALESCENT | 4 |
| TROUSERS. OPERATING | |
| TROUSERS. PAJAMA | 32 |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |

SIGNATURE
H P Morris

AF FORM 1 FEB 53 581

Figure 13-7 Linen Supply Record

## SUPPLY RESPONSIBILITY

You have been reading, now, a great deal about supply as you will see it in an X-ray clinic. Throughout the various paragraphs you have read about responsibility for supplies and equipment. It has been emphasized that YOU are responsible for any supplies or equipment you are around. Supply responsibility is outlined in AFR 67-10 and its changes. Some pertinent information is taken from that regulation and quoted here so you can see just what your supply responsibility is.

AFR 67-10, Section II, Para. 5b.

SUPERVISOR RESPONSIBILITIES. A person who exercises supervision over property received, in use, in transit, in storage, or undergoing modifications or repairs is responsible for (1) the selection of qualified personnel who will perform duties under his control; (2) the proper direction of such personnel; (3) the issuance of any instructions to these personnel that may be required to insure compliance with existing regulations governing property as set forth in AFM 67-1 and other Air Force directives.

AFR 67-10, Section II, Para. 5c.

CUSTODIAL RESPONSIBILITY. A person who has acquired physical possession of property is personally responsible for such property if the property is:

(1) Issued for his official or personal use and habitually under his control.

(2) ****************************************************************

(3) Acquired by an individual under circumstances requiring his personal care, custody and safeguarding.

AFR 67-10, Section III, Para. 13

CUSTODIAL RESPONSIBILITY. ***************************************
This applies equally to the RECIPIENT of property for his use or consumption. Such recipient, on receipt of property for official uses, assumes custodial responsibilities which may be extended to pecuniary liability in the event of NEGLIGENT LOSS, IMPROPER USE, OR IMPROPER DISPOSAL.

You can see that even if you are not assigned specifically as the responsible property officer, you are STILL responsible for the equipment and supplies with which you work.

## BEHIND AND AHEAD

You have now covered a great deal of administration that you will find in your X-ray clinics. The material that is in this book is just a small part of the every day work you will encounter in the different clinics to which you may be assigned. The day-to-day knowledge will come only with experience. You should know now how to process a patient through your clinic, file films and radiographic reports, some of the medical reports your clinic will submit and how your supply procedures will function.

## QUESTIONS

1. What ethics are required of you in your relations with the doctor, patient and other technicians?
2. What things must you think about in scheduling your patients for examinations?
3. What is SF 519a? How is it filled out and what do you check on the form?
4. What do you do if the form is improperly completed?
5. What information is placed in the daily log book?
6. How are identification numbers assigned to a patient?
7. Describe the process the patient and SF 519a go through in an examination.
8. Why are index card files used in the X-ray clinic?
9. How are the SF 519a's distributed and filed?
10. How are films filed?
11. What is a film locator log and why is it necessary?
12. What Air Force manual is used in the disposition of film and records?
13. Is it necessary to follow the procedures outlined in the manual mentioned above?
14. How are X-ray files maintained in the clinic?
15. How are X-rays disposed of in the clinic?
16. When do you send films out?
17. What types of Air Force publications will you see?
18. What manual is used in preparing a letter?
19. What manual is used to establish a filing system for correspondence?
20. What is the Professional Activities Report?
21. What is the Outpatient Report?
22. What report is completed on AF Form 675?
23. What are consultant reports?
24. Explain what budgeting is.

25. What are expendable supplies?

26. What are non-expendable supplies?

27. What are medical and Air Force supplies?

28. How do you go about budgeting for supplies?

29. What are two week stock levels and how do you establish them?

30. What form do you use to order supplies and how is it filled out?

31. What are control numbers?

32. What is AF Form 115a?

33. What is AF Form 93?

34. What is a base medical plant account?

35. What are custody receipt account numbers?

36. When and how do you take inventory of your equipment?

37. What is AF Form 90A used for in your supply procedures?

38. What is DD Form 1150?

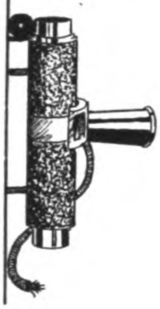
39. What is local purchase?

40. What are the procedures for using local purchase?

41. What is AF Form 581?

42. Describe what a UAL is and how it is used?

43. What are your supply responsibilities?



# CHAPTER 14

## YOU AND THE FIELD

The previous chapters in this manual have been devoted to the more academic and fixed unit type of procedures you need to know to operate in a Zone of Interior hospital. This chapter is devoted to your place and operation in the field. It is an important chapter.

One of the most difficult things for the average airman to keep in mind is that he is being trained and paid to be ready for war. This is as true of the X-ray technician as it is for the crew chief or armament airman. Your entire existence is for the purpose of providing X-ray service to keep our flying members in the air. When these people move into combat situations, you must be ready to move with them. Medical support does not stay home. Our Air Force is built to be flexible and mobile. Flexibility means that our units can be shifted where they are needed most. Mobility means that the units can pick up and move rapidly to a new location. Medical support must be as flexible and mobile as the bomber and fighter units.

A re-evaluation of attitude is necessary on field training. It is not a program which you can take lightly. You may be the sole technician with your group. It will be your job to provide X-ray support to the unit. You cannot just have an idea about what you must do, you must KNOW. The seriousness of atomic warfare must not be shunted to the back of your mind as something which is impossible to combat. As an airman you are expected to perform your duty in all situations and under all types of conditions. Your thinking and actions have to be re-oriented to immediate and gigantic destruction, massive numbers of casualties and panic. You must realize that aggression will be directed to our air bases, industrial centers and facilities of our government. Because of these facts, you may be rushed to Kansas City, Washington, D. C., or Cleveland, or to London, Paris or Rome.

Control of the air is an important factor in modern concepts of warfare. The enemy is also fully aware of the dangers of massive and immediate retaliation which can be effected by our Air Forces. Air bases will be priority targets. This means that your base or bases within your geographical area will be under direct attack. You may be shifted to these attack sites, or if you survive your own attack, help within your own area. You must be ready.

There are other areas of potential calamity you should be prepared to meet. These are the national disasters which have frequently spread about our nation. Medical support is required by our civilian populations, as in the destruction wrought by the explosion that occurred in Texas City, tornadoes such as the type which smashed Waco, Texas, and the great floods which swept New England into mass wreckage in 1954. In these areas normal facilities were destroyed or reduced. Disaster support by the armed services provided added facilities with mobile units. These types of events provide motivation for learning what to do in any emergency.

You should see now that the ability to do your job ANYWHERE AND ANYTIME is important. You will need some knowledge of how to do this in the field. Atomic warfare and natural disasters require that you know field operations.

## ORGANIZATION OF FIELD MEDICAL SUPPORT

Field medical support is that support providing medical care to personnel in the field. This care is basically the same as given in a permanent hospital. There must be some kind of organization of various type units to give this medical care. These units must be designed so that they provide sufficient care, yet be flexible, mobile and self-sufficient for various periods of time. It is a plausible conclusion that when a squadron of fighters and bombers moves to a new location that a 500-bed hospital with all its equipment and facilities cannot tag along.

### BLOCK AND DUAL UTILIZATION PRINCIPLE

Medical care in the field is based on a "building block" and dual utilization principle. The "building block" principle simply means that small units can be combined into larger units or larger units can be broken down into smaller units. Dual utilization is nothing more than having medical airmen work with the combat unit when it moves from a home base, and when that unit returns to the base to work in the fixed hospital. The basis for this idea is that when a squadron moves out it reduces the base population and need for airmen, so they can accompany the squadron. When the squadron returns the base population increases, so the airmen can be utilized in the fixed facility. Thus, you may go with the combat units into the field and on your return go back to the hospital clinic.

### SIX BASIC UNITS

Field medical support is provided by six types of units. These units can be broken down or combined to form a number of different size facilities to meet different requirements. These basic units are:

- Squadron Element
- Headquarters Element
- 36-Bed Airborne Infirmary
- 50-Bed Tactical Hospital
- 100-Bed Tactical Hospital
- 150-Bed Tactical Hospital

SQUADRON ELEMENT. Each squadron has a fly-away dispensary that is called the Squadron Element. This element has one officer and three airmen. It provides dispensary care for its individual squadron and is capable of caring for approximately 300 men. This element is supplied so that it can be independent for a thirty-day period. You can look at it as the squadron's personal "doctor's office". Usually three to four squadrons will make up an Air Force wing. Thus if three squadrons moved into a combat area, three squadron elements (one for each squadron) would move also.

HEADQUARTERS ELEMENT. The Headquarters element is a fly-away dispensary of the same type as the Squadron Element. However, it is the controlling unit of the tactical hospital. It accompanies the wing headquarters unit to provide staff assistance (advise unit commander on medical problems) and medical support (care for patients in the headquarters section). This unit has one officer, usually a ranking medical officer who is the hospital commander, and three airmen. This unit acts as the "doctor's office" to wing headquarters personnel.

36-BED AIRBORNE INFIRMARY. In the previous two elements you have undoubtedly surmised that there is little use for an X-ray technician. However, you will find that the 36-bed Airborne Infirmary will be the basic unit. This unit will operate with three officers and fifteen airmen. There is only one Radiology airman with this unit and he will be at least a five-level airman. If you are this X-ray technician, you will be alone and need to fend for yourself in performing your X-ray procedures.

The 36-Bed Airborne Infirmary is not a unit for complete support. It is the advanced party, so to speak. It provides for a more complete type of medical treatment than a dispensary, however, immediately upon arrival at its destination. When the infirmary is combined with one or more squadron elements, it is independent for a period of ninety days without re-supply. It provides the basic clinical facilities of a hospital such as Radiology, Surgery, Pharmacy, Laboratory, Medical Ward, Surgical Ward, Dental Clinic, Out-Patient Clinic and Food Service. It is designed to care for a 900 to 2200 man movement. As mentioned previously, it can remain self-sufficient for ninety days.

50, 100, 150-BED TACTICAL HOSPITALS. These hospitals are formed by combining various units and supplementing the 36-Bed Airborne Infirmary with additional personnel. These tactical hospitals are authorized according to the type of wing that is being used. A fighter wing, with less personnel than a medium bomber wing, would have a 50-bed hospital. A medium bomber wing would have a 100-bed hospital, etc. Two radiology airmen are assigned to these units.

## MOVING OF UNITS

Orders to move your unit are part of the Operations Orders issued for deploying a unit. Your commander will give your unit a briefing on where you are going before each move.

FORWARD BASE SURVEY. You will not enter an area without proper prior survey. An officer or a forward element will look over the site of your unit before a movement is accomplished. They will investigate:

- Physical facilities to determine if existing shelters are available or if tents will be required.
- Availability of water, drainage, heat, power, etc.
- Ability of a forward base to re-supply the unit.
- Type and amount of additional supplies which may be needed.
- Necessity of bringing all or just part of the Airborne Infirmary.

TYPES OF FORWARD BASES. There are three types of forward bases - Operational, Rotational and Standby. In peacetime, these units are staffed and supplied with personnel and equipment consistent with peacetime missions.

TRANSPORT. At the present time, three types of aircraft are used to transport infirmaries to operation sites. These are the C-119, C-124, and the new C-130. You will be informed before each movement on the type of aircraft you will be assigned.

Your equipment is combined in the infirmary group and you will be called on to help the loadmaster in loading and unloading the equipment. You will be working as part of a team and will be required to perform any duty necessary to get your unit in the air and on its way.

## SUPPLY REQUIREMENTS AND PROCEDURES

Your unit is self-sufficient and is always supplied to move immediately. The equipment is prepared, packed and assembled so that it is ready to go at all times. This requires a great deal of preliminary planning.

### RADIOLOGY SUPPLIES AND EQUIPMENT

The Equipment Component List (ECL) 20-90-28 itemizes the supplies and equipment for the 36-Bed Airborne Infirmary. This list is the guide by which the unit is set up. Each item that is essential is on this list. There is included at the end of this chapter a list of X-ray supplies and equipment. All of the equipment for the mission is listed under what is known as the UNIT MISSION EQUIPMENT (UME). The equipment which is air transportable is known as the UNIT ESSENTIAL EQUIPMENT (UEE). All of this equipment is originally authorized under the ordinary Unit Allowance List (UAL). Now refer to list beginning on page 14-11.

Temporary changes in authorization and allowance documents, to meet a mission requirement, are usually made at a unit level. The mission will usually create various additions or deletions from your Unit Essential Equipment so you must expect a change.

The electrical power for your machine is supplied by several sources. Generally, in peacetime, your unit will be supplied from a commercial source. However,

in manuevers or combat you will depend upon individual field sources. These sources may be the power unit which supplies the entire infirmary with a separate lead to your machine, or small portable gas generators like the new B-12 generator. These small generators will have a capacity of 2.5 KW. and furnish 20.8 amperes. These usually suffice for a 15 MA field unit.

The allowances you have seen are based on past experiences and present day anticipation. Only the essential equipment has been included.

## REQUISITIONING, RE-SUPPLY AND STORAGE

Preparing your X-ray unit for movement, and keeping it ready when not in use are most important factors. The preparation and readiness of the X-ray unit is primarily the responsibility of the medical supply officer, however, you will be a necessary part in advising him.

STORAGE. The radiology airman will help check on the amount of supplies and inform the medical supply section on any shortages or overages he has noticed. He will see that the material is complete and in a serviceable condition. Rotation of deteriorating items, such as film, will be made to keep the supplies fresh and ready to go. These exchanges are made with the fixed facility. Replacement is made in advance of the expiration date of the film and the change is recorded on a local form in a manner similar to that illustrated below.

| STOCK NO. | ITEM | LOT NO. AMOUNT | EXPIR DATE | DATE CHECKED | BY | REMARK |
|---|---|---|---|---|---|---|
| 6525-601-9015 | Film, X-ray 75 s, 14 x 17 | V20 4 pkg. | 10/1/57 | 7/1/57 | JDB | Exchanged with X-ray |

PACKING. The equipment is packed in metal chests and fiberboard boxes which are waterproof. Each container is numbered. The darkroom tents may be shipped in a wooden chest and barracks bag.

MARKING. Every chest or package is marked so that it can be identified. This marking may be done by the medical supply section, and usually is, but you may be required to do this for your own equipment. The identification usually includes the designation of the wing, tactical hospital and number of the package. The weight and cubic feet of each container is marked clearly. This is important because aircraft loadmasters must know just how much equipment is being shipped to load the aircraft properly. Any unnecessary or obsolete markings on the containers must be removed from them.

DOCUMENTATION. A shipping document, which is a list of the contents of each package bearing a unit mark, is prepared in six (6) copies by the medical supply section. The first copy is placed inside the chest or package and the second copy is fastened to the outside. These will indicate exactly what is in each chest or package. The rest of the copies are used by medical supply and the transportation officer.

## REQUISITIONING AND RE-SUPPLY

This is performed at your home base and in forward areas. Although you have sufficient supplies to last you for a specified period, you may be required to obtain more, or replenish items in case you remain longer in the area, meet unexpected situations or build up to a tactical hospital status.

FORWARD BASES. Arrangements are generally made for a forward base to supply your needs so that your supplies may remain intact. On arrival at a forward base, personnel responsible for drawing medical supplies contact the base medical supply and learn the base's procedures. The forward base will assign a cost account code and supply account numbers which you will use on your issue slips.

You will not have any particular dealings with this forward supply. You will operate through your Medical Materiel Supervisor who is assigned to your unit. He is responsible for obtaining the equipment and supplies. He will keep a ledger on all items consumed or worn out and use it as a basis for re-supply. He will keep track of all non-expendable equipment on AF Form 1120 and, generally, he is the person who has signed receiving documents for the infirmary.

In cases where you have used your own supplies, you will be supplied by aircraft.

HOME BASE. The return of your unit to your home base will require replenishing items that have been used. Your report to the medical materiel supervisor on the items consumed is again the basis of re-supply. Before you are relieved, you must inventory your supplies and equipment, inspect the equipment for serviceability and replace any worn out or damaged equipment, and resupply the chests and packages so they are ready to go again on a moment's notice. The materiel supervisor will transfer property responsibility of the equipment and the mission is finished.

## IMPORTANT MATERIEL PRINCIPLES

There are some very important principles which you must keep in mind pertaining to your supplies and equipment. You will share the responsibility of applying these principles with your medical supply and commander.

- Assure that authorized items of materiel are on hand, serviceable and packaged.
- Assure that all of your items and assemblies have proper markings and are easily identified.
- Review your materiel constantly so that it is the best available to meet the purpose.
- Assure yourself that you understand the mission and are familiar with the materiel you are authorized.
- Assure that you are familiar with the principles of AFR 67-10, "Responsibility for Public Property in Possession of the Air Force".

## FIELD CONDITIONS AND OPERATIONS

Experience is a prompt teacher. An airman will learn many new and probably unforeseen things. The most dangerous thing an airman can do is to remain unadaptable to field conditions and operations. Your mind must be constantly alert and your eyes wide open. There is going to be many situations which you cannot handle in a "State-side manner". Ingenuity and ability to do the best you possibly can with what you have is the criteria for the radiology airman in the field.

### ASSEMBLING AND DISASSEMBLING YOUR MACHINE

You will be using the USAF Picker Portable, 15 MA machine. Instructions for the erection and tearing down of this equipment are included in each chest. The instructions will be printed on the lids of the containers. You will need no tools. The equipment is designed to be erected or dismantled in a short period of time and with a minimum of personnel. All of the cables and connections are coded and arranged so that the female and male connections make it impossible for you to plug in the wrong cable.

Each piece of the equipment is marked with letters or the name of the piece so that you cannot make mistakes if you read your instructions carefully. Within each unit will be an operations manual which you will use to calibrate your control and tube unit.

AREAS OF CAUTION. Electrical connections should never be made until the unit is completely assembled. The X-ray tubehead should be placed on the tube column at an easily-reached level. Make sure that the horizontal arm is locked down tight. Check to see that you have a power supply of at least 110 volt, 50-60 AC cycle and a separate line to your control. Use care in protecting locking pins and latches. When these are bent or broken the unit cannot be fastened properly and damage may occur in transporting the chests. Place the fluoroscopic screen in an area where it cannot be stepped on when assembling the unit. This same caution is necessary for the bucky.

### DARKROOM EQUIPMENT

The darkroom equipment is contained in two separate packages. One package is a chest in which you will find the supports, and the other is a barracks bag in which the tent is found. The instructions for assembling are provided in the top of the chest.

The tent is rubberized and lightproof, but it may tear or rub until a leak is present. A kit is provided for repairing leaks. Ventilation for the tent is provided in some instances with fans or a regular vent exhaust.

Your darkroom technique must be modified to fit the climate or geographical area. In the deserts you must be watchful for blowing contaminants, whipping winds, etc. In tropical regions your solutions will become infected with rapidly multiplying algae, and these plants must be removed from the top of your solutions. Algae are also a nuisance in the tanks, and the sides and bottom must be cleaned with sand or a hard brush to keep algae from affecting your films. You must attempt to maintain

the necessary temperature control. You may control the solution temperature by using available ice, nearby streams, or improvised circulation systems. The temperature in artic regions and during the winter in temperate climes provides another source of trouble. Solutions will not develop at too low a temperature, so some means of warming them will be necessary. A metal pan can be used in which hot coals may be placed beneath the tanks. If the temperature is raised sufficiently to develop, remove the pan.

You will not always be placed in areas which require you to fight the elements. Many of your facilities will consist of captured, temporary or permanent shelters but you will have to devise for yourself many of the items you wish to add to those in your issue. Water, temperature control and drying will constitute your three major areas of inconvenience. You can add organisms and dust to these in some areas.

## PROTECTION

Electrical and radiation protection is still essential. However, you will not always be provided the extensive facilities you have in your hospital. In arranging your equipment you must see that your machine faces to the outside of the infirmary area. A good degree of protection is provided if you observe the principles of distance and wear your apron. Limit the beam with cones and use your creativeness for further protection. A sod imbankment dug from the surrounding area can provide a makeshift barrier. Your electrical protection is to make certain that your lines and equipment are properly grounded. Check your cables for breaks or worn insulation each time you return from a combat area. Make sure that you have proper drainage around your tent so that the tent area remains dry.

## POWER SOURCES

Generation of sufficient power to maintain your unit will be one of your major problems. Although most of the equipment is built to sustain your requirements, gas generators are rather unstable devices. You may be supplied with a unit which provides power for all the electrical devices in the infirmary. You may be stationed on a forward base where diesel units generate adequate power. Small, individual gas generators are also used. These will require care so that they do not become overloaded. If you find that your power is inadequate, check to see if you have a separate lead or if other users have overloaded your line. You will find an overloaded line more frequently when one unit supplies the entire infirmary. A medical repairman is usually a part of your team so these things may be referred to him. Operation instructions are printed directly on all of the small generator units.

## OTHER DUTIES

You will receive varied duties in the field. Your AFSC will not be limited to the X-ray duties. You may even be given some collateral training in another specialty so that your unit will be able to shift you in case of emergency. You will be helping throughout the entire unit in setting it up and assisting other technicians in their duties when you are not needed in your section. You will be required to care for patients, load or unload ambulances or carry litters. Everyone will use the assistance of others in caring for patients. Your unit will be a team and you will be an important member.

All of the men in the unit if needed, will help in pitching tents. Army Field Manual 20-15 outlines the procedure for most any type of tent which the Air Force will use in the field. This manual should be procured from your publications section in medical supply.

Field sanitation is as essential for you as for any other unit in the field. Army Field Manual 21-10 is a guide to the various structures and procedures needed to provide proper field sanitation within your unit. As part of a medical team you are expected to maintain your area as expertly as possible. Observance of proper personal hygiene, water discipline, waste disposal and use of proper protective measures against communicable diseases necessitates a great deal of personal self-discipline. In enemy or foreign country you will be subject to a variety of diseases if you do not take proper care of yourself. It is a rather surprising fact to know that there will be a far higher rate of disease and ordinary injury incurred within the unit than from combat injuries. You will not be able to care for others unless you learn to care for yourself.

Because you will be required to assist in other areas besides X-ray, you will find that a review of your basic first aid will be useful. Air Force Manual 160-24 should be available in quantity in your hospital. Study this manual again so that you become familiar with the proper techniques. Take an active interest in your unit training programs so that you will know what to do when the time comes for you to use your knowledge.

## COMBAT CONDITIONS

Your future enemies are not steeped in the ethics of humanity to man. When you are in a combat zone, you are subject to dangers just as the fighting units are. You will need to keep this in mind. An X-ray machine under a hospital cross may provide you with little protection in case of attack. Anything can happen in war and you have to accept this fact.

As a member of the medical service, <u>your first duty is to your patients</u>. You will keep this uppermost in your mind. Panic and fear must be kept under control. You must listen with care and be thoroughly familiar with procedures you will use in case of attack. You must learn to evacuate patients quickly from exposed areas into areas devised to protect them.

There are no means available to let you feel the terrifying fear and confusion you will experience in your first combat situation. This fear and confusion has come to each and every man who has been confronted with hot metal and exploding death. However, when a man realizes that this fear and confusion will be present, he can control it so that it will not smother his actions. Each succeeding experience will provide him with the courage and strength he must have. Creation of a deep and sincere belief in his duty to his patients has helped many a medic. Your patients will be looking to you for care and protection. You must give them this security by handling them swiftly, quietly and calmly. Helpless bodies and minds will reach out to you and you must be there for them to touch.

Capture of any member in a forward area is a possibility. Techniques of enemy prisoner practice are well published. Care of your patients will still be your duty even if you are captured. You must never give up attempts to care for them as much as is

physically possible. Indoctrinate your self thoroughly with the Code of Conduct so you bind yourself to your patients and them to each other. Spirit breeds spirit. Apathy breeds destruction. A medical man, in the field, X-ray technician or otherwise, must be a man others look to for care and security under any condition. Use whatever knowledge you possess to provide this care and security.

## SUMMARY

You have read about the future possibilities of atomic warfare and know what your responsibilities are. You know now how the medical service supports the field by using the building block and dual utilization principles. You recognize that the 36-Bed Airborne Infirmary is your basic unit and how it can be increased, with the aid of squadron elements and a headquarters element, into a tactical hospital of 50, 100, or 150 beds.

You know the types of forward bases you will operate from and how each is surveyed prior to moving a medical unit to it. You have a concept of how you will operate in the field from the list of equipment and supplies. It shows you only that material which is considered to be essential and air transportable. You know that temporary supply changes are affected by the mission and that these changes are made at unit level. Supply preparedness is clear to you because you know each item is checked for freshness and serviceability. You know the procedures to be used in re-supplying your unit and the preparation of each chest immediately upon return from a mission. You know how each chest is packed, marked and documented so you know what each one contains.

Instructions are readily available for the erection and dismantling of your equipment in each chest. You know some of the areas of which you must take care, such as using the proper line voltage and current, etc. Ideas on how to care for your darkroom equipment and procedures to be followed are now in your mind. You are aware of the types of protection that are available. Power sources are available in many forms and you are familiar with the various types you will use and some of the problems encountered.

You should also realize the necessity for working as a part of a team and the duties involved. You realize the importance of caring for your patients in combat conditions in such a manner that they know you are there helping and encouraging them.

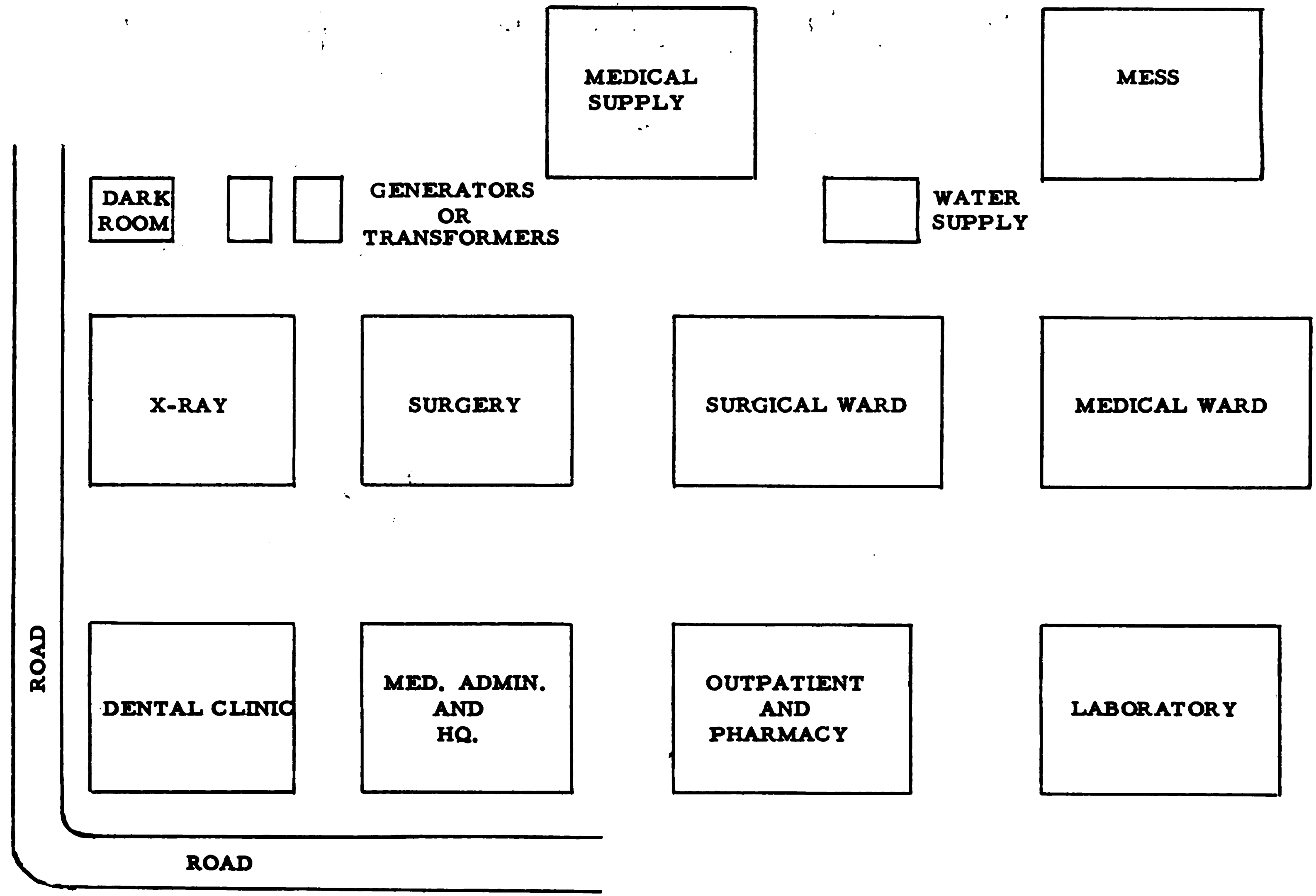
EQUIPMENT COMPONENT LIST (ECL) 20-90-28

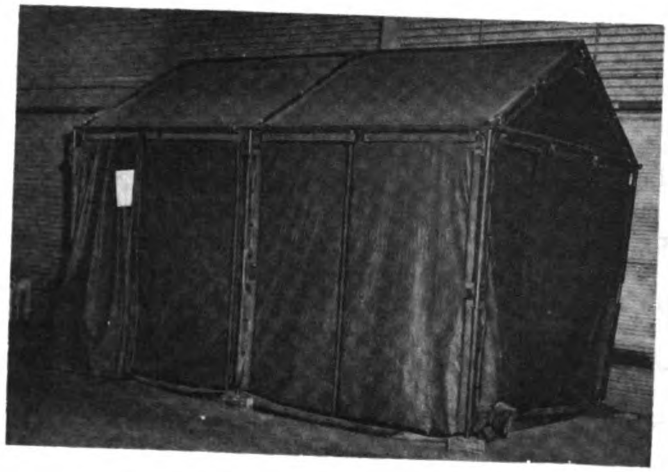
| STOCK NO. | NOMENCLATURE | QUANTITY |
|---|---|---|
| 6515-612-0000 | Pencil, Skin Marking | 2 |
| 6525-299-8594 | Hood, Fluoroscopic Screen | 1 |
| 6525-600-7900 | Caliper, X-ray Technique | 1 |
| 6525-600-9000 | Cassette, Radiographic Film, 8 x 10 inches | 2 |
| 6525-601-0000 | Cassette, Radiographic Film, 10 x 12 inches | 2 |
| 6525-601-1000 | Cassette, Radiographic Film, 14 x 17 inches | 2 |
| 6525-601-2124 | Chest, X-ray Film Protective, 1/32 inch head lining | 1 |
| 6525-601-3680 | Control Unit and Tube Transformer Head, X-ray Apparatus, 15 MA, 110-220 volt, 50-60 cycle, AC | 2 |
| 6525-601-5010 | Film Dental, Radiographic, Fast Emulsion, 1-1/4 by 1-5/8 inches, 144's | 2 |
| 6525-601-5015 | Adapter, Dental X-ray Film Bitewing, 100's | 2 |
| 6525-601-7015 | Film, Radiographic, Ultrafast Emulsion, 8 x 10 inches, 75's | 2 |
| 6525-601-8015 | Film, Radiographic, Ultrafast Emulsion, 10 x 12 inches | 2 |
| 6525-601-9015 | Film, Radiographic, Ultrafast Emulsion, 14 x 17 inches | 2 |
| 6525-603-1760 | Hanger, Film X-ray, Processing 8 x 19 inches | 4 |
| 6525-603-1765 | Hanger, Film X-ray, Processing 10 x 12 inches | 4 |
| 6525-603-1775 | Hanger, X-ray Film, Processing 14 x 17 inches | 4 |
| 6525-603-1795 | Hanger, X-ray Film, Processing Dental | 2 |

| STOCK NO. | NOMENCLATURE | QUANTITY |
|---|---|---|
| 6525-603-2425 | Holder Set, Dental Radiographic Film Exposure, Bitewing Type Set of two | 2 |
| 6525-603-3000 | Holder, Radiographic Film Exposure, 8 x 10 inches | 3 |
| 6525-603-4000 | Holder, Radiographic Film Exposure, 10 x 12 inches | 3 |
| 6525-603-4300 | Holder, Dental Radiographic Film Exposure, 10's | 1 |
| 6525-604-000 | Illuminator, X-ray Film, Fluorescent 110-volt, 60-cycle, AC | 1 |
| 6525-604-2150 | Tank, Insert, X-ray Film, Processing, Corrosion-Resisting Steel, 5-gal. | 2 |
| 6525-604-2155 | Tank, Insert, X-ray Film, Processing, Corrosion-Resisting Steel, 10-gal. | 1 |
| 6525-604-7925 | Letter Set, X-ray Film Marking, Lead, R and L | 1 |
| 6525-608-0620 | Marker Set, X-ray Film Identification | 1 |
| 6525-611-1225 | Numeral Set, X-ray Film Marking, Lead, 0 to 9 | 2 |
| 6525-612-1710 | Developer, X-ray Film Processing, Rapid Speed, Powder, qs. 1 gal. | 10 |
| 6525-612-1880 | Fixer, X-ray Film Processing, Powder, qs. 1 gal. | 10 |
| 6525-615-8100 | Table, Field X-ray Apparatus | 1 |
| 6525-616-9250 | Tube Stand Unit, Medical X-ray Apparatus, Mobile-Portable | 1 |
| 6530-299-8304 | Tank, Clinical Solution, Rectangular, 18 x 10 x 5 inches | 1 |
| 6545-914-3470 | Chest, Medical Instrument and Supply Set Field, No. 2, 30 x 18 x 6, Empty | 1 |

| STOCK NO. | NOMENCLATURE | QUANTITY |
|---|---|---|
| 6545-914-3480 | Chest, Medical Instrument and Supply Set Field, No. 3, 30 x 18 x 10 inches, Empty | 1 |
| 6545-959-6800 | Darkroom, X-ray Portable, Tent Type, Field | 1 |
| 6545-959-6860 | Repair Set, X-ray Darkroom, Tent | 1 |
| 6656-418-2000 | Timer, Interval Clock | 1 |
| 6740-299-8495 | Safelight, Darkroom, Photographic Wall, 110-V, 60-cycle, AC | 1 |
| 7510-612-4000 | Envelope, Photographic Negative, 14-1/2 x 17-1/2 inches, 100's | 1 |
| 7510-612-7500 | Ruler, Plastic, Transparent, 18 inch | 1 |
| 8405-715-0450 | Apron, Laboratory, Plastic | 1 |
| 8415-600-2000 | Apron, X-ray, Protective | 1 |
| 8415-603-0011 | Glove, X-ray, Protective, Leather, Left Hand | 1 |
| 8415-603-0012 | Glove, X-ray, Protective, Leather, Right Hand | 1 |
| 8465-603-0990 | Goggles, Industrial, Darkness, Adaption | 1 |
| 9535-604-7000 | Lead Sheet, 1/16 x 36 inches | 2 |

ARRANGEMENT OF TACTICAL HOSPITAL UNDER FIELD CONDITIONS





DARKROOM TENT

X-RAY MACHINE

AUXILIARY EQUIPMENT

## QUESTIONS AND PROJECTS

1. Why is it so important that a Radiology Airman know how to operate in the field?
2. What other calamities besides warfare should a Radiology Airman prepare for?
3. What is field medical support?
4. What three characteristics should a field unit possess?
5. What is the building block and dual utilization principle?
6. Explain what a squadron element is.
7. Explain what a headquarters element is.
8. Explain what a 36-Bed Airborne Infirmary is.
9. How are 50, 100, 150-bed tactical hospitals created?
10. What determines the size of medical unit to be used?
11. What information is sought in a survey of a forward base?
12. What are three types of forward bases?
13. What is ECL 20-90-28? What is UME? What is UEE?
14. What machine is used for field medical units?
15. What does the term B-12 mean to you?
16. What responsibilities does a Radiology Airman have in storing his X-ray equipment at a fixed hospital?
17. How do you get new supplies at a forward base?
18. What do you do about your supplies and equipment when you return from a mission?
19. Where do you find instructions for assembling and disassembling your X-ray machine?
20. What are some of the things you have to be careful of in setting up your unit?
21. What methods could you devise for drying your films in the field?
22. What type of problems would you encounter in the desert?
23. What type of problems would you encounter in the sub-zero regions?

24. What type of problems would you meet in the tropics?

25. How would you protect yourself in the field?

26. What reference can you use in learning how to pitch a tent?

27. Why should you review your first aid procedure?

28. Explain what your duty is in a combat situation?

29. Why does a Radiology Airman need to develop a wider knowledge of other medical career fields and procedures?

## WORK PROBLEMS

1. Go to supply and check on your field equipment. If you have a field unit, take it outside and assemble and disassemble it so you can do it in 15-30 minutes.

2. Sit down and visualize a tactical problem. Think of all the things that could possibly happen. Write these down. Go over your list and see what you would or could possibly do in each situation.

3. See if you can locate men who have had combat experience, either as a part of a fighting unit or as a field medical man. Evaluate what they say against equipment and methods you know about today. Project their thinking into an atomic attack. Determine if anything they said could be effective action for you or your equipment.

4. Read FM 20-15, 21-10 and AFM 160-24.

5. If you do not have a field training program, set up a mock alert. Make a list of things you think you would need. See how long it would take you to get everything together and packed. If this suggestion frustrates you, check into your field training program and see what is set up for your section.

# APPENDIX

## HOW TO CONDUCT ON-THE-JOB TRAINING

### RESPONSIBILITIES

On-The-Job Training is the specific responsibility of the supervisor of the radiology airman. This is clearly defined in the Job Descriptions in AFM 35-1. The commander, the squadron training officer and the officer in charge of the radiology airman must see that training is properly carried out and reported in such a way that the airman receives full credit for training completed.

### PLANNING THE PROGRAM

The supervisor must carry out a good training program if he is to have a versatile section capable of achieving its mission and performing effectively in emergencies. He must know the characteristics of a good OJT program and the step by step procedures for putting it into effect.

A good OJT program has certain well-defined features. Each person in the section knows his responsibilities. The airman is assisted to develop motivation. The program is carefully planned and integrated into the daily operation of the section. Teaching methods of proven effectiveness are used. Up-to-date study materials are given to the student. Testing is carried out with written tests and practical exercises in which the airman has a chance to show that he can correctly perform required procedures. Prominent progress charts are posted and training records maintained. Training is reported to the squadron OJT officer. A follow-up of training reports is made to insure that the airman and the section get credit due them for their training efforts. Finally, and of greatest importance, the airman is required to apply his learning in the daily work of the section, and is permitted to help solve the problems arising in the daily operations.

#### STEPS IN PLANNING

With the above scope in mind, the OJT supervisor can proceed to the planning phase of this training program. This you do in the following steps:

1. Read, first of all, the following section on motivation. This will give you a general idea of how the OJT program can be made dynamic. Then carefully read Chapter I of the text, <u>Radiology</u>.

2. Carefully look over the other chapters of the text. You will find ample

lesson material, presented in such a way that it can be integrated into the work of the section.

3. Your next step will be to outline the lessons to be taught. This is done by developing AF Form 623, "Formal On-The-Job Training Record" as described in the section on Records and Reports of this Appendix. Ask your squadron training officer for administrative forms and required reports. Air Force Regulation 52-2 states that Form 623 may be kept in your office.

4. Next you should study the section on training methods and principles in this Appendix. Determine the methods that you can use for the various procedures and facts which you must teach. Have these well enough in mind so that you can apply them singly or in combination to any teaching situation. This gives you the versatility to develop real student learning in any operational-training situation.

5. Prepare lesson plans as discussed in the following sections. A lesson plan is your plan of what to teach, how to teach it, and how to develop practical application of the material.

6. Review the study questions and projects at the end of each chapter. Use all the written questions for your paper and pencil tests. Select suitable projects that permit the airman to show his mastery of the required skills and knowledge.

7. Read the section in this Appendix on training materials, decide which training aids you need, and place requisitions with your publications section or supply officer. You are now ready to start training.

   - Follow your lesson plan carefully and make assignments a week or two in advance.

   - Make assignments from this text.

   - Assign practical work and insist on applications of learning.

This text is designed to give the students their lessons in "functional order." This means that the text follows the same order as the work assigned to airmen during the first months of his duty in your section. However, some of the procedures in this text may not be applicable to your particular clinic due to the lack of equipment or because you do not perform some of the listed procedures. Analyze the basic functions of your section and concentrate on those areas first. Then expand your airman into the other phases which he will encounter at stations other than yours.

## MOTIVATION

Few OJT programs are successful unless the airman who is being trained assumes a large share of the responsibility for the success of the program. He must definitely want to learn. He must be able to see an advantage to himself in learning, and he must gain satisfaction in applying what he has learned. While some airmen

can never be motivated, the average American develops a high motivation if properly handled. If you will observe the various offices around the medical installation, you will note that motivation is uniformly high or uniformly low. Enthusiasm is caught, not taught, so be enthusiastic about your subject and you will observe the same enthusiasm being generated in your student. Here are some reliable procedures for creating motivation.

## ORIENTATION

There are two types of training orientation - career orientation and orientation in the section and on-the-job. Chapter 1 lists the items that must be covered in career and job orientation. These should be reviewed by the supervisor and his orientation lesson should be carried out soon after the arrival of new airmen in the section.

The airman must understand his place in the radiology section, and his position in relation to his fellow workers. He must understand how the radiology section fits into the hospital or other medical unit, and the relationship of his organization to the Wing and Base. He must know his hospital is related to the Medical Service as a whole, and where it fits into his concept of a fighting Air Force. When he has this over-all picture, he must be shown how his growth of knowledge and skills definitely helps his organization. The airman must be made to feel that he is an important part of the outfit. Show him how it is to his advantage to learn the radiology field, both from a military career standpoint and after retirement as a civilian. Most younger airmen are proud and anxious to be doing something for their country, so you must show them clearly that their success on the job is a real service to their nation.

## JOB STANDARDS ORIENTATION

If you want a man to learn quickly, give him the over-all picture. Don't keep him guessing by parcelling out details. He deserves to know just what he is expected to learn and in what techniques he is supposed to become skilled.

In Chapter 1, the Job Standards do precisely this. They not only outline the major areas of learning, but they also tell just what should be learned in these areas. They state the degree of training that the apprentice, the specialist and the technician must attain. They form the blueprint or lesson plan for the OJT course. They insure complete coverage and provide checks against wasting training time on unimportant topics. After you have given a man his orientation and, using job standards, have told him what he is to learn, the next step is to organize his job in such a way that learning is possible. This may have some effect on the organization of your section.

## ORGANIZING FOR MOTIVATION

We cannot separate learning from the operations of any section. A bad operational situation is a bad training situation, and vice versa. The way that the supervisor organizes and operates his section markedly affects his training program. There are many types of supervisors. We will consider four of them, from worst to best. TYPE 4 develops his working conditions that give the greatest motivation for on-the-job learning.

- Type 1 - This type is the dictator who says, "You are not here to think; you are here to work". This dictator tries to do the thinking for everybody and tries to do everything but the most drudging details himself. He does not realize that strong, continual "bawling out" creates fear in people to the extent that careful, thorough thinking is impossible. People near panic, people who are continually smoldering with anger, act emotionally. Acting emotionally means acting on impulse rather than carefully thinking through a situation. It means the tendency to jump to quick and often stupid conclusions. This strong dictator type is trying to prove he is the only one who knows anything, and that everybody else is stupid. Are your subordinates so fearful of you, or so full of hatred for you that they think with confusion? If so, you can expect little learning. Clear, calm thinking and learning must go hand in hand. Personnel who work for TYPE 1 are but little more than errand boys.

- Type 2 - Type 2 trains his personnel to do one job or skill. Their performance of duty is similar to the production line. The work they do has little or no meaning to them. These sections have low morale, and when an unusual situation arises in the absence of key personnel, the workers are unprepared to act with versatility.

- Type 3 - This supervisor allows his personnel considerable chance to think and make decisions in their special area of work. Morale is fairly good here and the workers are fairly happy, without showing much enthusiasm. Most of the workers do not know much except in their own job area. Because of lack of versatility, this section can be hurt very badly in combat conditions, or if there is a large withdrawal of key personnel for emergency troop movements, or in case there is a sudden change of mission.

- Type 4 - This supervisor realizes that his section must be versatile; he thoroughly orients all personnel on the mission of his section and the work of everyone in the section. He rotates his personnel through as many jobs as possible so that he may be two or three deep in each position. He takes emergencies and changes of mission in stride. He usually is combat ready. He delegates responsibility and along with it the authority to carry out any responsibility he delegates. He trains personnel, not just to do a few limited procedures, but also how to solve the problems faced by the section. He insists they participate actively in the problems faced in the daily operation of the section. He considers his personnel as individuals, each with the potential for handling most situations that arise in the section. He gives credit where credit is due and uses the axiom that "nothing succeeds like success", rather than holding threats over people for not doing this job. The morale of his section is high. His people accept guidance and correction without losing initiative. Here you find good problem solving, rapid learning, and even creative thinking. His airmen want to learn and are in a situation where learning conditions are at their best. The worker doesn't have to be told he is important to the mission - he knows he *is*!

If the supervisor is to best organize for work and learning, he must be the TYPE 4 Supervisor. OJT fits perfectly in such a situation but it is difficult to organize correctly for effective work and learning under the supervision described in TYPES 1, 2, and 3.

# TRAINING MATERIALS

On-The-Job training has three distinct advantages over school training. First, the trainee receives more individual attention from his supervisor; secondly, he has much more opportunity to apply what he is learning; and third, there is usually more equipment available per trainee for applicatory work. However, formal schools usually have more experienced teachers, written material, training aids, films, etc. Air Force field medical schools prepare handouts for their students. These handouts are not usually given to units in the field since they are merely working supplements to the formal lectures and are not suitable for general distribution. Requests for supplementary medical materials should not be directed to these schools, but should be sent forward through regular military channels.

## WRITTEN TEXT MATERIAL

In preparing this OJT manual, most of the books and publications of key importance in the radiology field were studied. From them were extracted the essential learning materials that the trainee should know. The supervisor who uses this manual will not find it necessary to spend his time assembling written materials for this training program. The text material in the OJT manuals, plus standard publications, regulations and standard forms found in every radiology section should satisfy the requirement for written material.

## FILMS

A small number of films on radiology are available through commercial sources. There are, however, a large number of films on other basic elements such as physics, anatomy, nursing, etc. which can be used to supplement these areas. Films may be quickly obtained from audio-visual depots, and service is usually excellent. Wing training officers usually have projectors to loan. Study the film catalog, determine the time requirements, and place your order as far as possible in advance. It is emphasized that a film should be used as a teaching instrument. The student should be required to look for specific items in the film. After the film has been shown, a discussion of its lesson should be carried out. All films should be previewed by the supervisor since the applicability of the film cannot always be determined by its title or the abstract description carried in the catalog.

## TRAINING AIDS

One major problem encountered by the OJT supervisor is to find specific techniques within his own section that he can use to graphically illustrate to his trainees the various principles, techniques and procedures he wants them to learn. With a little ingenuity and creative imagination, each clinic can provide ideal and handy training situations that can be very interesting and useful. Some of these experiments and projects have been included in the text. There are many more that can be used from the resources available in your clinic, hospital or base. You cannot rely entirely upon this text for complete explanation of all techniques and principles. No manual can provide the thousands of minute facts and techniques that you know at this moment. These have been gained by you from your day to day experience.

You may often approach your training hours with the question, "What can I use to demonstrate this principle?" Let's look at your clinic and see what you have on hand in your clinic or near by on the base that you can use.

EQUIPMENT. Each piece of equipment in your section is used to obtain specific results. This equipment is on hand where it can be handled and operated. These include your machines, cassettes, filters, calipers, electric mixers, hypodermic needles and syringes, spot-film devices, cassette changers, darkroom dryers, tanks, timers, thermometers, portable machines, photofluorographic machines, body section devices, pelvimetry devices and hundreds of others. Using demonstration, application, and testing you can easily train your man to operate and use each piece of equipment properly.

PRINCIPLES. The principles of electricity, magnetism, anode-heel effect, FFD, part-film distance, part thickness, secondary radiation, contrast, density, distortion, film artifacts, chemical and light fog, pathological conditions as they effect technique, anatomy, physiology and positioning require a great deal of thought to teach. What is there available that you can use to illustrate these principles? Your base electrical shop has many devices you can borrow. Switches, wire, batteries, plugs, meters, and other equipment can be obtained from them. You can use a piece of broom handle to demonstrate the solenoid by wrapping a wire around it. Use a coat hanger bent into the shape of the armature and placed between two books to show how the various generators work. Go to the motor pool for an old generator to use in explaining a direct current generator.

To demonstrate the various factors of radiographic technique, use your film and machines. Develop experiments for focal-film distance by placing an object under the tube and taking the film at various heights. Show a chest film taken at 30 inches and one taken at 72 inches. Use a step wedge to demonstrate the penetration of KVP at various values; take a film and block it off and then use various thicknesses of filtration to show what effect it produces on the beam. Do the same thing for density but change exposure times or MA. To show the effect of a grid on the film, place an old intensifying screen close to the side of the tube so the student can actually see the beam coming from the port. Elevate the grid with blocks and place another old screen beneath it on the table top. The trainee will be able to see the tube above and the screen below at the same time. For this demonstration, a low technique is best so that enough time can be used to be effective. Move the tube about at different angles over the grid to show cut-off, ratio and radius.

Distortion is easily demonstrated by letting the student take one film perpendicular and the others angled at various degrees of tube angulation. Let him take one film and identify one structure. Then have him try to identify the same structure in the other radiographs. This will show him how the beam distorts, and give him some concept of its geometric pattern. You can demonstrate part-film distance with the intensifying screen or with film. Place the object at different heights in the beam so that the screen outlines its shape, or suspend an object above a film at various heights and let him take films of it. Place them together on the view box so he can see the range of magnification and loss of detail.

Use your film files to show poor positioning, to teach radiographic anatomy, to illustrate pathological conditions and fractures, and to show how media outlines the various systems. To give the student some insight to technique variances required from pathology, fill a water bottle or balloon with air and have him make an

exposure. Then have him fill the bottle with water to see that the film gives a heavier density. Another film of the water with a low ratio barium mixture will show a concept of heavier deposits in a liquid medium.

Administration can be taught by allowing the student to fill out the various forms until he can do it correctly. A good way to get him to understand the procedure for making reports or for ordering supplies is to trace him through the procedure a few times and then have him write an SOP on the steps required. Review of the SOP will show various omissions or errors. You can correct these with the airman and have him write it again until he has it correct. This same technique is useful in intensifying his knowledge of certain special examinations you can do in your clinic.

He can learn the various nursing procedures by visiting the wards, and the outpatient section, and will gain experience in the operating room by accompanying more experienced technicians. When you lack certain equipment that he may need to know about at other stations, check around your area for civilian hospitals which may have such equipment and arrange for a visit with them.

As you can see, you have a classroom that cannot be duplicated in a formal school. Your patients give the trainee first hand knowledge of patient conditions and reactions to the procedures and techniques used in your clinic. Look closely at your clinic and let your imagination produce the thousands of teaching aids that will enable your men to know their jobs intimately.

## TRAINING METHODS AND PRINCIPLES

### TEACHING PRINCIPLES

Before about 1885, students spent their time memorizing such things as Caesar and dainty French sonnets. Memorization was the chief learning method and lecture the principal method of teaching. Then the school teachers began giving follow-up tests a few months after work of the course was completed. To their amazement, these teachers found that their students were retaining only about ten per cent of memorized material. With only ten per cent retention, we might say that ninety per cent of all time, money, and effort expended on education was utterly wasted.

At about the same time that this education awakening was taking place, practical business men and employers in industry began to demand and were successful in getting the schools to teach more realistic subjects. So, as the students began studying and applying such subjects as mathematics, science and accounting, they became more enthusiastic about their studies. They actually liked school and began to take upon themselves a great deal of the responsibility for their own learning. In short, they became highly motivated, since they could see real value to their learning. These facts in education psychology are very important to you as a supervisor. Now let us study teaching methods, keeping the above facts in mind. Suppose you are teaching trainees in the function and repair of a carburetor. Let us review five of the teaching methods that could be used:

## TEACHING METHODS

1. Memorization with understanding: With this method you would make the student memorize the 57 parts of the standard carburetor. Learning by this method is slow; retention is very weak and the value of the procedure to the trainee is very small.

2. Lecturing. You could lecture to the student about a carburetor and the function of each of those parts. Lecturing usually results in very poor retention and understanding, since most lecturers use words that are too large for the students, use much too long and complicated sentences for comprehension, and frequently talk too rapidly to permit understanding of difficult materials.

3. Demonstration, explanation and testing. You could demonstrate and teach him the over-all function of a carburetor and the relationship of each part to the whole function of the carburetor. You would then test carefully to see that the student understands. This method is markedly better than the first two, and results in an increased learning rate and fair retention.

4. Demonstration, explanation, testing and practical application. After teaching by method No. 3 above, you could give the student an opportunity to use a carburetor, manipulate it, repair it, and rebuild it. In this step you would also require him to demonstrate how it was used and how to maintain it in working order. This method results in excellent learning and good retention. It is an excellent method for teaching skills and knowledge.

5. Learning and then teaching. The procedure consists of first teaching by method No. 4 above, then requiring the student to teach others what he has learned. With this method we can expect long retention of the knowledge and the skills so learned.

An intelligent supervisor cannot help but observe that this last method is ideally suited to the OJT situation. Thus if OJT is properly conducted, it can be one of the most valuable educational procedures. Go through the following steps:

1. Explanations
2. Demonstrations
3. Application
4. Testing
5. Coach and Pupil method

In OJT situations these steps may be spread over a considerable period of time.

## COACH-AND-PUPIL METHOD

In the coach-and-pupil method, one student becomes the teacher, the other the pupil. Lessons or skills are taught by explanation, demonstration, and application. Then the roles are reversed and the procedure repeated until each can teach and demonstrate the required knowledge and skills. It goes without saying that this method can only be carried out after the students have been taught or thoroughly studied the

subject matter prior to the use of the coach-and-pupil method. The coach and pupil method can also be used for evaluation and practical testing. Other training methods which prove profitable are:

1. Use of training films preceded by detailed explanation of what to look for, and followed by group discussion.

2. Group discussion of the solution to problems as they arise in daily operations.

3. Assignment of project reports, whereby a student researches some topic, writes it up and reports to his section.

4. Field trips to observe other units performing functions of which the student should be aware or learn.

5. Research and then write report on assigned references.

6. "Over-the-shoulder techniques" wherein an experienced airman looks over the shoulder of the student performing a procedure or duty and listens to an explanation of the work. He then gives corrective suggestions.

7. Teaching, wherein a lower level airman is assigned as a pupil of a more advanced student.

TRAINING OUTLINE

The Job Standards listed in Chapter 1, when placed in chart form on AF Form 623, provide excellent training outlines for the On-the-Job trainee. In the section on Reports and Records, this procedure is described in detail.

THE LESSON PLAN

Lesson plans cover a plan of operation for teaching. They are developed from the Job Standards and must be fitted to the type of training needed and the abilities of the student on one hand, and the type of working experiences available in your section. on the other hand.

In developing lesson plans you work from the completed job standards. Each lesson plan should include certain key parts as indicated below.

1. OBJECTIVE. Skills or knowledge taken directly from the Job Standard.

2. TEACHING METHOD. Method or combination of methods to be selected from those discussed in this Appendix. Also applicatory projects which are preferably a part of the daily work of the section.

3. LEARNING METHODS. Study assignments in this text, other reference reading and equipment used in application projects, films, etc.

4. TEACHING PLAN. Tell the who, what, where, when, and how of the

lesson as it actually will be carried out.

5. EVALUATION. Utilize test questions which are found at the end of each chapter and the applicatory projects for testing matters of procedure.

TESTING

A very wise Inspector General once said, "If a man works hard preparing for an inspection, he deserves a good inspection." You, no doubt, remember many times when you have had your men prepare for the visit of some person of importance only to have the VIP walk by the section without a sideward glance. You, no doubt, lacked considerable enthusiasm the next time such a visit was forecast.

If your students work hard preparing for an examination, they deserve a good one, so give them a chance to show how well they have done. Such success responses give high motivation to future learning.

At the same time evaluation does other things:

1. It tells how effective you are as a trainer and often indicates whether failure on a test is due to student failure or teacher failure.

2. It indicates which areas need more attention.

3. It forms a factual basis for your reports to go with your personal opinion.

4. It gives the student a target at which to direct his efforts.

5. It motivates the student to study hard.

6. It gives you a point of departure for the next phase of training.

Following is a summary of the use of different kinds of examination questions:

TRUE-FALSE. The average person can guess 50% of true-false questions by answering them all true or all false. They are good for review purposes but not valid for important examinations.

MEMORY QUESTIONS. If a teacher gives memory questions he causes cramming, and, as we described earlier, cramming is very quickly forgotten.

ESSAY QUESTIONS. Good for survey - but do not try to compare one main essay question against another. Test experts have found that personal prejudices of the test grader enter in so strongly that essay questions are dangerous to student success. You may penalize too heavily for small errors in content, English, spelling, etc. The student will spend his time trying to guess what you want. Few teachers can grade an essay test accurately, and inaccurate grading destroys student initiative.

MULTIPLE CHOICE. The effectiveness of this type test depends on how

well they are written. Some are too easy to guess. Others have two or three correct answers. One type of multiple choice question is highly valuable and is described below as situational questions. Generally, multiple choice questions can be made the most reliable and valid of any question.

PRACTICAL TEST. The best test is not the one which tests isolated facts. The best evaluation is the one which tests the ability of the airman to use the learning and skills in a realistic problem-solving situation.

SITUATIONAL TESTS. In a situational test an individual is given a problem situation drawn from the actual operation of his section. To solve the problem he must use the knowledge and skills he has been learning. This test answers the key question, "Is he learning anything of practical value to his daily work and for his career?" Normally this test (1) sets up a problem situation, (2) describes various solutions, labeling them solution a, b, c, and d, or (3) requires the student to pick one of the four multiple choice answers as the action which he would take.

## FITTING INSTRUCTIONAL METHODS TO YOUR SECTION

Perhaps you may only have one or two trainees, each partially trained, and you wish to start training them immediately. In that case, the above procedures may be varied to fit instruction to the needs of the individual student. You will find On-The-Job training admirably suited for tailor-made, individualized instructions. Here is one way to do the fitting:

1. Find out how much the trainee knows about his job. Timely questioning with this purpose in mind can save you much effort. Subtract what your trainee knows from the complete job picture and the remainder is that part of the instruction on which you must concentrate.

2. Questioning usually starts the trainee himself to asking questions. As the job progresses, the trainee's answers to your questions serve as a basis for evaluation of his work.

3. Have each individual trainee do some job planning as you think he needs it. He should outline, step by step, the procedures of each new job to which he is rotated throughout the section. When he has completed the outline, he should demonstrate how to do the procedure and be given a chance to teach it, in a dry run, to some other person. At the same time, he should be given a definite reading assignment in this OJT manual and tested upon both the written matter and the applied phases of his training.

## REPORTS AND RECORDS

Job Training Standards for the radiology career field are found in Chapter 1. These Job Standards are the key documents to OJT. From them can be compiled:

1. Part II of AF Form 623 (attached) - "Formal On-The-Job Training Record.

2. Item No. 1 of the lesson plan as prescribed in the preceding section, this Appendix.

3. Training Progress Record Wall Chart.

Any progress marks on Form 623 or the Training Progress Chart should always be based, at least partly, on some form of written or practical test rather than being based entirely on the opinion of some one individual.

AIR FORCE FORM 623

As prescribed by AFR 52-2, Air Force Form 623 is the standard form used for establishing a cumulative record of individual progress and proficiency of all airmen undergoing OJT. The "training objective" as used in Form 623 means that training required to qualify an airman in a new AFSC either higher in his own ladder or in a closely related ladder. One form is used for each training objective. These forms are maintained at squadron level or in the immediate work unit. When an airman is transferred, the AF Form 623 accomplishes the individual's field personnel records group. The gaining organization utilizes the information on the record as a basis for planning the remaining portion of OJT necessary to accomplish the initial training objective. The purpose of providing a recognized uniform Air Force OJT record is to insure that an OJT program once started, is continued and completed without undue interruption or duplication of effort, regardless of where or how many times an individual may be transferred. Only the key items from the job standards, preceded by Arabic Numerals, should be included in Part II of the Air Force Form 623.

AIR FORCE MANUAL 35-1 REPORTS

This manual is the key publication governing the airman career program. Since airmen may attain a skill and be awarded an AFSC through OJT as well as through training at an Air Force technical school, the directives in AFM 35-1 controlling assignment and utilization and upgrading of airmen are equally applicable in both situations. Since AFM 35-1 is the key manual in airman classification, and is the description of the job of every medical airman, the parts which describe the career patterns for the radiology career field must be shown to the students. This manual contains descriptions of educational requirements, physical requirements and other basic information in addition to material covered by job descriptions. Reports as required by this manual will be submitted to the squadron personnel officer. Normally, the supervisor is notified by the personnel section as to this reporting requirement.

TRAINING PROGRESS RECORD

As each training item of the major paragraphs and sub-paragraphs of the job standards are satisfactorily completed, they should be recorded on a training progress wall chart. The progress of a group of trainees can be put on such a chart and posted in a prominent place in the section.

You should contact your squadron training officer to determine methods of re-

# FORMAL ON-THE-JOB TRAINING RECORD

INSTRUCTIONS

ON-THE-JOB TRAINING OBJECTIVE

Enter the training objective. *Examples:*

1. Qualify helper level airman at apprentice level in AFSC 73230.
2. Qualify apprentice level airman at senior level in AFSC 70250.
3. Qualify airman in suffix "A" to AFSC 43152 presently qualified in suffix "B."
4. Qualify senior level airman at advanced level, AFSC 42371.
5. Qualify airman in AFSC 73230 presently qualified in AFSC 70230.

SECTION I

*Item 5.*—Enter grade held during this training.

*Item 8.*—Enter training started as verified by entry to item 9.

*Item 9.*—Paragraph and number of personnel action memorandums.

*Item 10.*—Enter estimated completion date for purposes of planning and programming the training.

*Item 11.*—Signature of trainee, when training starts. Other items are self-explanatory.

SECTION II

COLUMN A.—Phases of training will be determined from the ATRC OJT Program Outline. Where this outline is not available for an AFS, phases of training will be developed from the current AFS job description. Additional training shown in item 22, DA AGO Form 20 will not be listed in this section.

COLUMN B.—Enter date training started for each phase.

COLUMN C.—Enter date each phase of training was satisfactorily completed, based upon the trainer's judgment that airman can effectively perform duties encompassed within each phase.

COLUMN D.—Trainer will authenticate entries in columns A through C by signing column D (*Name and grade*).

When training is completed, the signature of the responsible training officer will complete this section.

SECTION III

When applicable enter in Test Result column the word "passed" or "failed."

SECTION IV

When applicable enter in Action column, the word "favorable" or "unfavorable."

ON-THE-JOB TRAINING OBJECTIVE

Qualify Apprentice level airman at senior level in AFSC 90350

I. PERSONNEL DATA

| 1. LAST NAME—FIRST NAME—MIDDLE INITIAL | 2. PRIMARY AFSC | 3. UTILIZATION AFSC | 4. DUTY AFSC |
|---|---|---|---|
| Jackson, Jacob J. | 90330 | 90330 | 90330 |

| 5. GRADE AND SERVICE NO. | 6. SQUADRON AND STATION | 7. DUTY SECTION | 8. DATE TRAINING STARTED | 9. AUTHORITY |
|---|---|---|---|---|
| A/2c<br>AF 17220461 | 4303rd Medical Group<br>Outlandish AFB, Maine | Radiology | 8 Jul 57 | Para 9<br>Feram 158 |

| 10. ESTIMATED COMPLETION DATE | 11. SIGNATURE OF TRAINEE | 12. NAME AND GRADE OF IMMEDIATE SUPERVISOR |
|---|---|---|
| 15 Dec 57 | Jacob J. Jackson<br>JACOB J. JACKSON | Rouf A. Ready<br>ROUF A. READY |

II. TRAINING DATA

| PHASE OF TRAINING (A) | DATE STARTED (B) | DATE SATISFACTORILY COMPLETED (C) | TRAINER AUTHENTICATION (*Name and grade*) (D) |
|---|---|---|---|
| Performing darkroom processing procedures for all types of film. | 8 Jul 57 | 23 Jul 57 | Rouf A. Ready |
| Performing routine and complex positioning procedures | 24 Jul 57 | 13 Nov 57 | Rouf A. Ready |
| Determining and applying routine and advanced radiographic technique procedures | 24 Jul 57 | 12 Dec 57 | Rouf A. Ready |
| Performing administrative and supply procedures relating to Radiology | 18 Sep 57 | 30 Nov 57 | Rouf A. Ready |

AF FORM 1 FEB 54 623 Previous editions of this form are obsolete.

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porting of training progress and completion. Failure to report such progress can endanger your entire training program.

## CHECK LIST FOR OJT SUPERVISORS

1. Do I have AFR 52-2 and the Radiology Career Field description from AFM 35-1?
2. Have I studied the Job Standard and started Form 623 and developed a training progress record wall chart for my section?
3. Have I developed my lesson plans to cover all phases of the Job Standards?
4. Do my lesson plans include my learning objectives and teaching methods?
5. Have I studied the section on Teaching Methods and Principles to assure that I used the best method for each phase of the training?
6. Do I inspire my trainee by job, section and Medical Service orientation and by showing how lesson objectives coming from Job Standards assist him in career development?
7. Do I maintain interest by requiring lively, well organized lessons, demonstrations and applications?
8. Are my trainees showing definite evidence of gain in knowledge and are they demonstrating skill in application?
9. Is there continual effort to tie the job and the training together?
10. Am I using the evaluation questions at the end of the chapters to determine the effectiveness of my training?
11. Do I make an effort to plan and secure training aids?
12. Do I make a conscientious effort to control the trainee on the job by keeping training charts, reports and records up to date?
13. Do I adapt vocabulary and assignment to the level of the trainee?
14. Do I encourage and motivate the workers and the OJT trainees or do I kill their initiative and enthusiasm?

A sample of a partially completed training progress record is shown on the following page. A record such as the one shown, or one similar, is essential if individual progress is to be adequately evaluated.